POWER PLANT ENGINEERING

Established Over 30 Years

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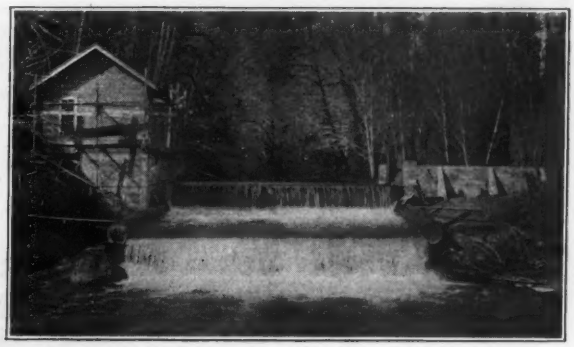


Just a Cottage Small by a Waterfall

BUT NOBODY lives in it and it would be considered unfortunate if anyone did live in it. This attitude is exactly opposite to that expressed in the song whose title we have quoted above. For the song says that a cottage like this would be the proper place to live—with the right partner, preferably of the gentler and more beautiful sex. This cottage, however, is a hydro-electric plant, the inhabitants being none other than a 75-kw. generator driven by a 113-hp. vertical water turbine. So the fewer people that have to live in it, the lower will be the cost of the power it produces.

But wouldn't it be a humdinger of a place to spend a vacation? Just above the dam, there must be a wonderful, clear sparkling pool for one's plunge in the morning—and probably at two-hour intervals thereafter. Below the dam, we are willing to wager that we could find a big rainbow once in a while to add variety and zest to the menu. And no clattering street cars or bellowing, smelling automobiles within a hundred miles. Oh, boy!

It is just such a location that often lends itself well to the development of small automatic hydro plants. In your vacation travels this summer, you may come across just such locations that would prove suitable for power developments. Don't forget that one engineer was awarded the Coffin medal recently for valuable service as a result of information on hydro power possibilities which he obtained while on his vacation in the North woods.

The little hydro plant shown above would seem to lend itself well to automatic control. It is by no means as small as some plants to which this control has been applied; conversely, it is by no means as large as others. The largest automatic plant we know of is described elsewhere in this issue.

Independent Towel Supply Co.'s New Power Plant

NON-CONDENSING 500-KW. TURBO-GENERATOR, INTERESTING COAL AND ASH HANDLING EQUIPMENT, COMBUSTION CONTROL SYSTEM AND LAUNDRY WATER HEATERS FORM POINTS OF INTEREST

ON ACCOUNT of its use of the most modern and economical types of power plant equipment, the new power house of the Independent Towel Supply Co. of Cleveland, Ohio, is of particular interest. Examination of the drawings and photographs will show that, although every convenience has been provided, the design has been simplified as much as possible. Automatic combustion control equipment, a full equipment of the necessary recording instruments, auxiliaries under control of suitable regulators and convenient arrangement of machinery relieve the plant operator of much unnecessary detail. For the greater part of the time, the plant is run with good economy and entire satisfaction by one operator.

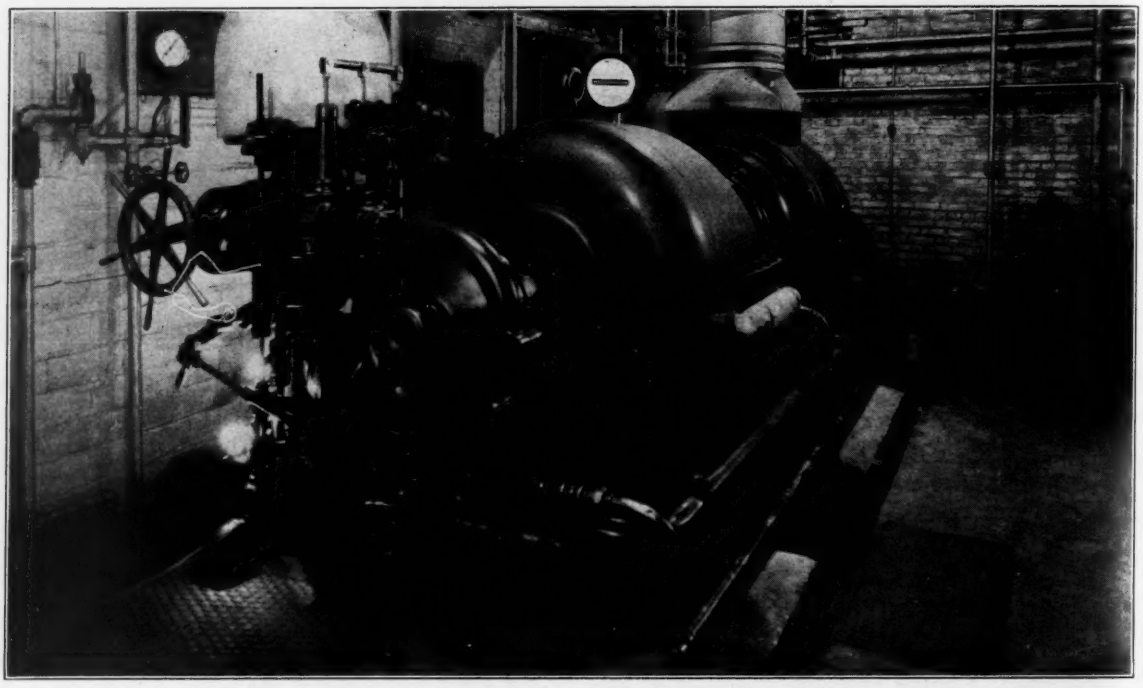


FIG. 1. NEW 500-KW. TURBO-GENERATOR UNIT OCCUPIES ONE END OF ENGINE ROOM WITH OIL FILTERS IN FLOOR PIT NEAR GOVERNOR END

Previous to the construction of the new plant, steam was supplied to two engine-driven generating units by two horizontal return tubular boilers. These became heavily overloaded but when it was decided to build a new plant, the only space found available was a strip of land 35 ft. wide adjoining the laundry building. Accordingly the boiler house was built here, as shown in the illustrations, the boilers being set with their backs against the laundry building.

Steel stacks are placed on the roof and guyed by stiff legs to the roof of the adjacent concrete laundry building. The roof of the boiler house is a poured concrete slab designed to provide maximum stiffness against wind reactions from the stacks. Over the boilers, the boiler house roof is depressed in order not to cover up the windows in the wall of the laundry building. Over the coal bunkers, the roof is higher and the north end next to the street extends up to the same heights, the upper part of this section containing the laundry water heaters.

Forced draft chain grate stokers were installed to burn Eastern Ohio bituminous coal, which has good heat content but sometimes gives trouble from clinkering. Since the plant has been put into operation, however, it has been found that West Virginia coal can be purchased. The latter gives a slightly lower cost of evaporation and has been burned satisfactorily on the stokers.

EXHAUST STEAM HEATS LAUNDRY WATER

Laundry water is heated in two closed heaters, passing first through an exhaust steam heater, which takes all the exhaust from the main and auxiliary units then through a live steam heater. Live steam is admitted by a thermostatically controlled valve only when there is not enough exhaust steam to bring the water to the proper temperature.

Last year the generating plant, consisting of two engine driven generators became badly overloaded; the switchboard and electrical system were also disarranged because of the addition of circuits without proper planning. Since it was desired to have all exhaust from the generating units go to the laundry water heaters and to have this exhaust free of oil so that it can be returned

to the boilers after condensing in the heaters, a 500-kw. non-condensing turbine with suitable switchboard was installed. In case conditions change so that better steam economy is desired in the future, steam pressure can be raised to 200 lb. as boilers and piping are built for this pressure and the turbine can be re-nozzled.

Two 500-hp., V-type water tube boilers are installed, with space left for a third similar unit, as shown in Fig. 4. Boilers are operated at 100 to 125 lb. pressure, depending on the load conditions. As noted above, West Virginia coal is burned on forced draft chain grate stokers under these boilers. These stokers are set with front arches as shown in Fig. 5. Side wall coolers are also installed, connected with the laundry water heating system which will be described in more detail later. Each stoker is driven by a 4-in. by 4-in. vertical steam engine as shown.

Combustion air for the stokers is supplied by a 28,000-c.f.m. fan driven at 1560 r.p.m. by a steam turbine. No induced draft fans are installed, flue gas being removed from each boiler by a steel stack mounted on the concrete roof directly over the boiler. Each stack is 4 ft. 9 in. in diameter and 120 ft. high.

FIG. 3. TWO WATER-TUBE BOILERS, FIRED BY CHAIN-GRATE STOKERS, ARE COMPLETELY EQUIPPED WITH AUTOMATIC COMBUSTION CONTROL APPARATUS

Combustion Control System Aids Boiler Operation

Operation of these boilers is as nearly automatic as it is possible to make it. A combustion control system is installed to adjust the stoker speed, forced draft fan speed and damper in accordance with changes in the load. A master regulator, actuated by variations of pressure in the main steam header, is installed on the boiler room wall. This master regulator then controls individual regulators on each stoker engine, a regulator on the main steam line to the turbine driving the forced draft fan and a regulator for each damper. A complete equipment of water level controllers, soot blowers, gages, meters and all necessary accessories and helps to good boiler operation, is installed, as shown on the attached list of equipment. Boiler are blown down into a blowoff tank as shown, which is vented to the atmosphere through a suitable exhaust head on the roof.

In the laundry a considerable amount of live steam is used for process work. This amounts to about 15,000 lb. of steam an hour, since the power generating units account for only about 15,000 lb. of the 30,000 lb. made by the boilers under normal operation. Most of the surplus goes direct to the laundry for heating, ironing

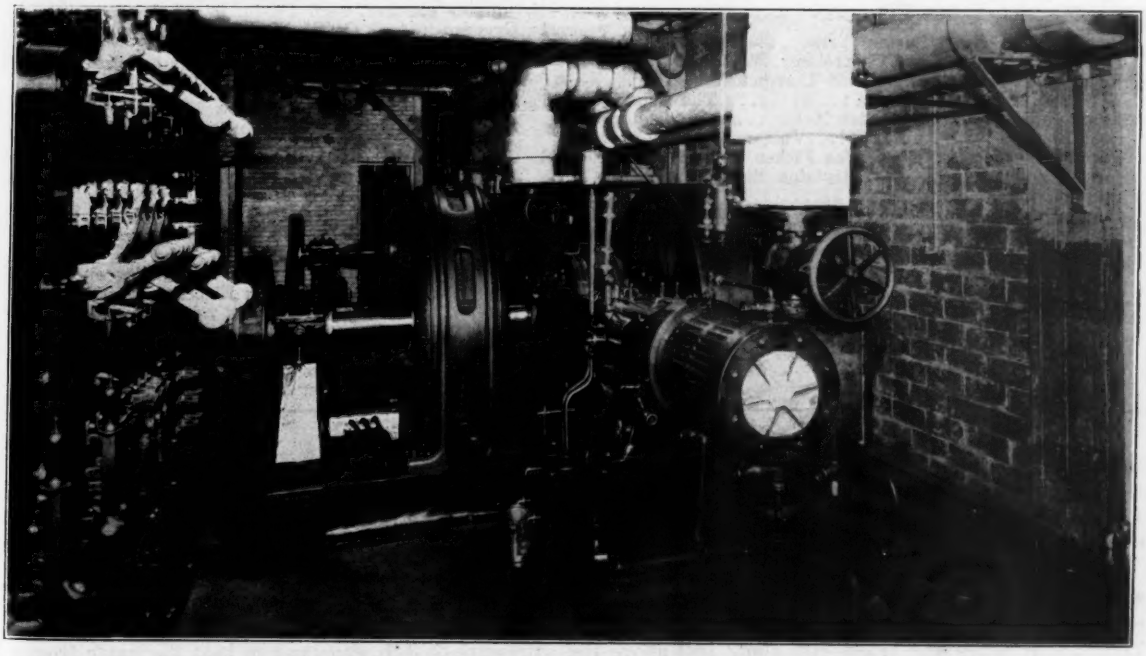


FIG. 2. TWO STEAM-DRIVEN GENERATORS ARE INSTALLED WITH BELT-DRIVEN EXCITERS. PART OF NEW SWITCHBOARD APPEARS AT THE LEFT

machines, and is sometimes used direct in the washers. A 6-in. steam line extends from the end of the main steam header in the boiler room, not shown in the drawings, and carries this steam to the laundry.

All water entering the plant, whether used for laundry water or boiler feed water passes first through the water softener. This consists of four tanks set in two batteries, employing the zeolite process. Behind the second battery of softeners is a motor-driven centrifugal booster pump which forces the treated water through two circuits.

The first circuit includes the stoker side wall coolers, which are formed of two 4-in. extra heavy pipes, with cast iron spacer blocks, laid along the sides of the stoker. These cooler pipes and blocks run along just above the grate, forming a strip of cooling surface about 12 in. wide. These coolers are piped to the water storage tank on the roof in such a way that a thermo-syphon effect is produced through the coolers. A small additional amount of water from the booster pumps is admitted to provide for water circulation in the coolers even if the overhead tanks should become empty. The side wall coolers absorb only a small amount of the furnace heat, probably less than 2 per cent, but they have proved most successful in preventing clinker formation just above the line of the grate.

The second circuit leads through a diaphragm valve to the exhaust steam heater located in the gallery above the feed water heater. This is a 287-sq. ft. heater of 25,000 g.p.h. capacity, designed to use exhaust steam from main generating units and auxiliaries at an average pressure of 3 lb. gage and to heat the water from about 50 deg. to about 150 deg. This heated water is primarily for use in the laundry processes and under normal op-

Principal Power Plant Equipment at Independent Towel Supply Co.

Boilers, Stokers, Draft Equipment

2 D. Connelly Boiler Co. 550-hp. water tube boilers, designed for 200 lb. gage pressure, operated at 115-125 lb. gage.
2 Riley Stoker Corp. Harrington stokers, 11 ft. by 9 ft., each driven by a 4-in. by 4-in. Clarage Fan Co. vertical steam engine, and set with side wall coolers furnished by stoker manufacturer.
Furnace Arches—American Arch Co.
Boiler Settings—Geo. P. Ford & Sons Co.
2 Boom Boiler & Welding Co. steel stacks, each 4 ft. 9 in. in diameter, 120 ft. high.
1 B. F. Sturtevant Co. Turbovane forced draft fan, 28,000 c.f.m. at 4½ in., driven at 1560 r.p.m. by Sturtevant steam turbine.
Coal and Ash-handling equipment, weigh larry — The Stearns Conveyor Co.

Pumps and Heaters

2 Dean Bros. Co. boiler feed pumps, duplex outside and packed, each 10 in. by 6 in. by 12 in.
1 Swartwout Co. 3-unit, 36-in. feed water heater.
1 Whitlock Coil Pipe Co. live steam laundry water heater, capacity 25,000 g.p.h.; 300 sq. ft. heating surface, 50 deg. to 200 deg., 100 lb. steam pressure.
1 Griscom-Russell Co. exhaust steam laundry water heater, capacity 25,000 g.p.h., 287 sq. ft. heating surface; 50 deg. to 150 deg., 3 lb. gage steam pressure.
1 American Steam Pump Co. booster pump, 20 g.p.m., 20 ft. head, driven at 1750 r.p.m. by Dayton Fan & Motor Co. ½-hp., 220-v. motor.
1 Centrifugal booster pump driven by Century Electric Co., 15-hp., 1735-r.p.m., 220-v. induction motor.

Miscellaneous Equipment and Accessories

Combustion Control System.....The Hagan Corp.
Stets Feed Water Level Controllers..Williams Gauge Co.
Recording Pressure Gages and Thermometers.....The Bristol Co.
Draft Indicators, Feed Water Meter....Bailey Meter Co.
Soot Blowers.....Vulcan Soot Cleaner Co.
Pump Governors.....The Fisher Governor Co., Inc.
Fan Regulator.....Boylston Steam Specialty Co.
Sylphon Temp. Regulators.....The Fulton Co.
Regulating Valves.....C. E. Squires Co.
Piping—High pressure steam, National Tube Co. steel pipe; water piping, Reading Iron Co. wrought iron pipe; installed by The Becker-Seidel Co.
Pipe Covering.....The Philip Carey Co.
Monel Metal Gaskets.....Akron Metallic Gasket Co.
Triple-Acting Non-Return Valves.....Golden-Anderson Valve Spec. Co.
Blowoff Valves.....Yarnall-Waring Co.
Safety Valves.....Scott Valve Mfg. Co.
Water Columns.....The Reliance Gauge Column Co.
Iron and Steel Valves and Fittings.....Crane Co.
Brass Valves.....Jenkins Bros.
Atmospheric Relief Valves.....Crane Co.
Exhaust Heads.....The Swartwout Co.
Steam Traps.....Armstrong Machine Works
Pressure Reducing Valves.....Davis Regulator Co.
Filters and Pumps for lubricating oil.....S. F. Bowser & Co., Inc.; Wayne Tank & Pump Co.
Water Softener.....Wayne Tank & Pump Co.
Engine Cylinder Lubricators.....Detroit Lubricator Co.

Engines, Turbines and Accessories

1 Ridgway Dynamo & Engine Co. 500-kw. non-condensing turbo-generator; throttle pressure 110 lb. gage, exhaust pressure 5 lb. gage; driving a Ridgway 500-kw., 0.8-p.f., 3-phase, 60-cycle, 240-v. generator at 3600 r.p.m.; 10-kw., 125-v. exciter mounted on main shaft.
2 Skinner Engine Co. center-crank, steam-tight-valve steam engines designed for 100 lb. throttle pressure, 3 lb. exhaust pressure. One 13 by 15-in. engine drives Western Electric Co. 125-kw., 1.0-p.f., 240-v., 3-phase, 60-cycle generator at 276 r.p.m. One 16 by 18-in. engine drives Western Electric Co. 168-kw., 240-v., 0.8-p.f., 3-phase, 60-cycle generator at 225 r.p.m.
2 Western Electric Co., 125-v. exciters, belt driven from engines; one 7-kw., 1150-r.p.m.; one 6½-kw., 1050-r.p.m.
1 Frahm Vibration Tachometer on turbine — James G. Biddle.
1 Ridgway Dynamo & Engine Co. turbine oil filter.
2 Worthington Pump & Mach. Corp. turbine oil pumps, duplex plunger, each 4½-in. by 2¾-in. by 4-in.
1 Griscom-Russell Co. Multiwhirl turbine oil cooler, size 103, 50 tubes, 35 lb. press.
1 Greene Gas Cleaner Co. 4-unit air filter for generator air.

Electrical Equipment

1 7-panel switchboard built by The Leonard Electric Co., furnished and installed by Enterprise Electric Const. & Fixture Co.
Oil switches, Condit Electrical Mfg. Co.; knife switches, Leonard Electric Co.; ITE circuit breakers, Cutter Co.
Voltmeters and ammeters, synchroscope, frequency meter, power factor meter, Weston Electrical Instrument Co.
Type TA 125 General Electric Co. voltage regulator, watt-hour meter, Sangamo Electric Co.
3 Enterprise Electric Co. Peerless transformers, 240-115-v., 25 kv.a. each.

erating conditions all the exhaust steam will be used in this heater. If this amount of steam does not heat the water enough, however, live steam can be sent to the live steam heater immediately over it, through which the water passes before going to the roof storage tank. The live steam heater also has a capacity of 25,000 g.p.h. and is designed to take steam at about 100 lb. pressure. A live steam header leads direct to this heater from the main boiler header, through a pressure regulating valve. Just before the live steam line enters the heater, a thermostatic temperature regulating valve is installed that admits steam enough to heat the water to any predetermined temperature up to 200 deg. These two heaters are also arranged with a thermo-syphon system of piping so that there will be circulation through them from the hot water tank even though fresh water is not being admitted.

In this second circuit, the hot water, after passing through the heaters, goes to the roof storage tank. Connections are led back from this tank to the side wall coolers. In an emergency, the boiler feed pumps can take water from the laundry water heaters. Emergency cold water lines direct from the booster pump behind the filters are also led to the side wall coolers and to the boiler feed pumps. All returns from the building heating system drain back into a receiving tank in the turbine room, whence they are pumped into the feed water heater by a 20-g.p.m., centrifugal motor-driven pump.

All condensate from the laundry water heaters flows to the open feed water heater located directly below them as shown in Fig. 5. This heater has a capacity of about 25,000 g.p.h. and is vented through an atmospheric relief valve to an exhaust head on the roof. Since the heater condensate is, for the most part, the exhaust from the main turbine and forced draft fan turbine, it contains no oil and can be used for boiler feed water.

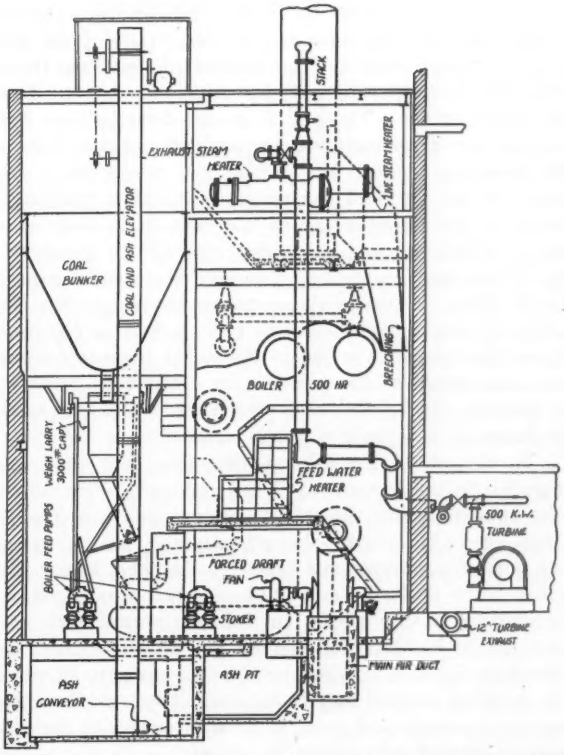


FIG. 5. SECTION THROUGH BOILER AND TURBINE ROOMS

Feed water from the heaters is sent to the boilers by two duplex outside end packed steam pumps, each 10 in. by 6 in. by 12 in. governed by suitable regulators. Feed water level is automatically controlled by water level controllers, with suitable water columns mounted at the boiler fronts and illuminated so that they can be seen from the boiler room floor.

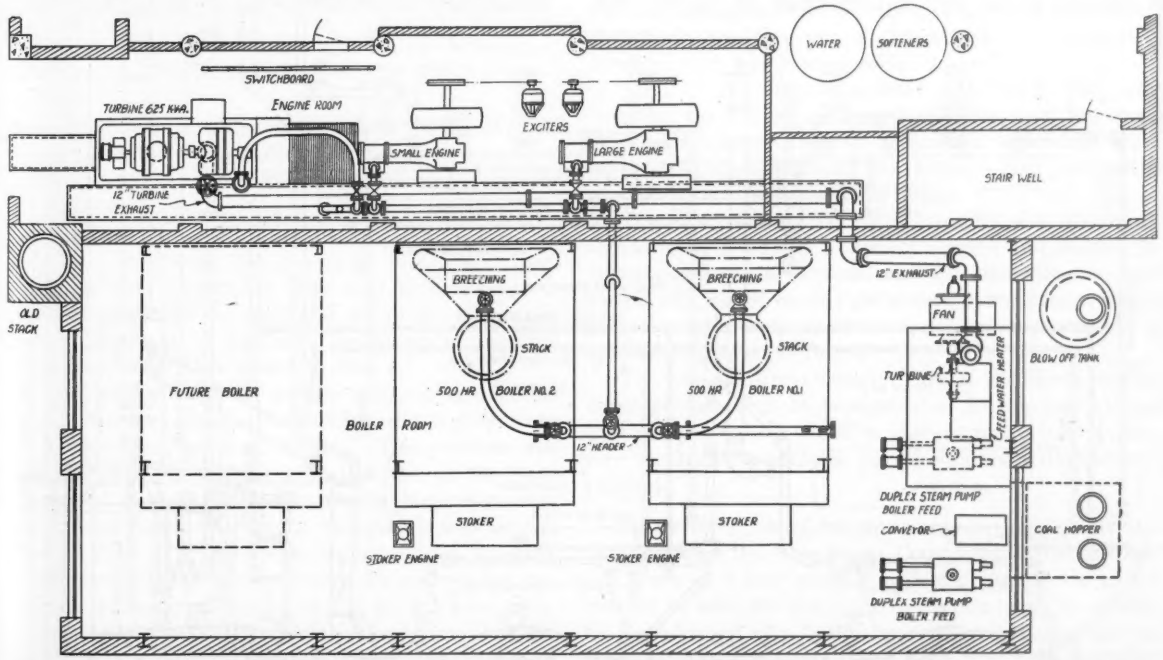


FIG. 4. GENERAL PLAN OF POWER PLANT SHOWING BOILERS AND PRIME MOVERS, WITH HEATERS AND BOILER AUXILIARIES AT END OF BOILER ROOM

Coal and Ash Handling Equipment

All coal and ash must be handled to and from the plant by motor trucks. The method of handling these materials in the plant itself, however, goes far to offset this disadvantage. The coal is chuted directly from the truck at the street-level to a hopper and elevator boot in the basement. From this point it is raised 54 ft. by means of an enclosed bucket elevator. The discharge spout of the elevator passes the coal to a drag conveyor, which extends approximately 63 ft. along the top of the coal bunker; this bunker has a total capacity of 500 t. Gates in the conveyor trough permit the coal to be distributed to any part of the bunker required. From this bunker it is fed to the stoker hoppers feeding the chain-grates of the two 500 hp. water-tube boilers—an accurate check being kept on the amount of coal used, by means of a recording weigh larry.

To dispose of the ash, another drag conveyor was installed in the basement. This conveyor, about 53 ft. long runs alongside the ashpit doors as shown in Fig. 7. Once or twice a day the accumulated ash is raked out onto the conveyor and taken by the same bucket elevator which feeds the coal bunkers to an ash-hopper adjoining the coal bunker. In order to permit both coal and ash to be thus handled by the same elevator, the discharge spout is provided with a two-way gate by which the material elevated may be directed either onto the upper conveyor or released so as to drop at once into the ash-hopper immediately below the spout.

Since ash must be removed by motor trucks under a cartage contract, and since there is no certainty as to the exact time at which the trucks will arrive, special arrangements are made so that the driver himself can start up the discharging conveyor and fill his truck without help from the inside. For this purpose, a discharge spout is provided on the outside of the building at a height of about 9 ft. above street-level, high enough to be well out of the way of interference by unauthorized persons, but easily reached by the driver when standing up in his truck. He backs up under the chute, closes a switch on the side of the spout, and starts the conveyor. As soon as the truck is filled he shuts off the conveyor and removes the truck.

Steam Engines Are Kept for Stand-by Service

Before the turbine was installed in this plant, power for the laundry equipment was generated by two reciprocating steam engines, shown in Fig. 2. These are installed in an engine room which is part of the basement of the main building and is immediately adjacent to the new boiler room. They are of the steam-tight-valve counterflow, center-crank type. One engine, 13 in. by 15 in., drives a 125-kw., 3-phase, 60-cycle, 240-v., a.c. generator at 276 r.p.m. This rating of 125 kw. is at 1.0 p.f. but since the power factor of the plant is usually near 0.8, this rating is really about 100 kw. The other engine, 16 in. by 18 in., drives a similar 240-v., 168-kw., 0.8 p.f. generator at 225 r.p.m.

These engines exhaust at about 3 lb. gage pressure, the exhaust going to the laundry water heaters as noted above. They are equipped with flywheel governors and have an automatic lubricating system incorporated in

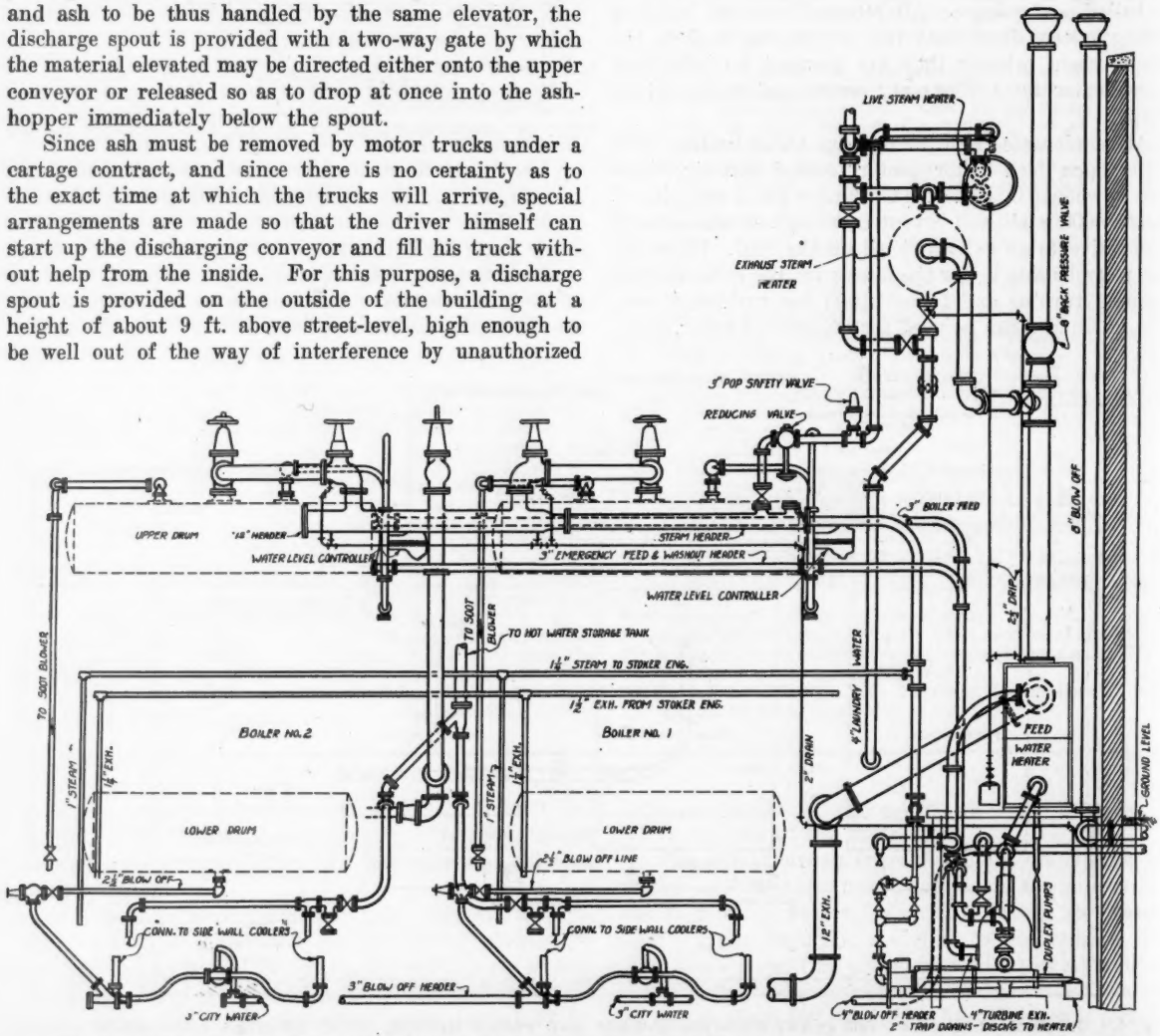


FIG. 6. ELEVATION OF PIPING AT REAR OF BOILERS SHOWING CONNECTIONS TO SIDE WALL COOLERS AND HEATERS

the engine, with separate mechanical force feed lubricators for cylinder lubrication.

Excitation for these units is furnished by two exciters, located between them and belt-driven from pulleys on the main engine shafts as shown in Fig. 2. For the 125-kw. unit a 6½-kw., 125-v., 1050-r.p.m. exciter is provided and for the 168-kw. unit a 7-kw., 125-v., 1150-r.p.m. exciter.

Turbo-Generator Installed to Meet Greater Power Demands

As the load on the above generators increased, it was decided to install a non-condensing steam turbine to take over the load, leaving the engines for stand-by service. Accordingly, the turbo-generator shown in Fig. 1 was installed last year at the other end of the engine room. This is a 500-kw. unit, designed for a throttle pressure of 110 lb. gage and an exhaust pressure of about 5 lb. gage. It is so constructed that it can be re-

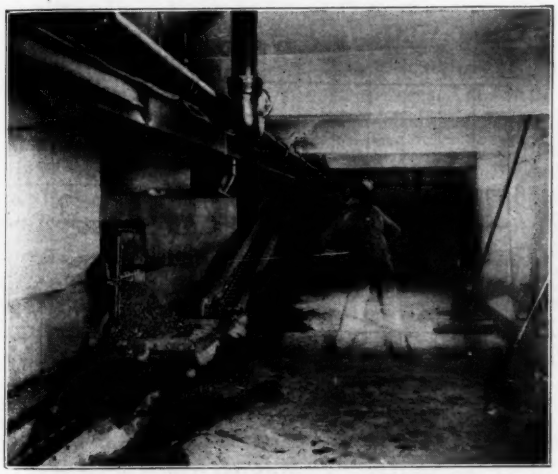


FIG. 7. ASH IS TAKEN BY DRAG CONVEYOR TO BUCKET ELEVATOR, WHICH LOADS IT INTO OVERHEAD STORAGE BIN

nozzled in case future demands make a higher throttle pressure advisable. This turbine drives a 240-v., 3-phase, 60-cycle, 0.8-p.f., a. c. generator at 3600 r.p.m. Its exciter, a 125-v., 10-kw. unit is mounted on the main generator shaft.

Air for ventilating the generator is brought from the outside through an air filter and then through a duct running under the floor and up to the generator. This ventilating air is led from the generator into the boiler room by the duct shown in Fig. 1.

It was desired to set the turbine lubricating oil filter below the turbine, but as the turbine and engine room had no basement, this was difficult. The problem was solved, however, by making a shallow pit in the floor at the end of the turbine, just under the turbine governor mechanism shown in Fig. 1. In this pit was set the turbine oil filter supplied by the manufacturer, together with two small duplex steam pumps for circulating the oil. Each pump is a 4½-in. by 2¾-in. by 4-in. unit, only one being needed at a time. The pumps are set in the pit with a grating over them allowing the operator at any time to tell whether or not they are operating properly and also allowing easy access for maintenance. These pumps force the oil at about 35 lb. pressure up to a multiwhirl oil cooler mounted on the wall and thence to a tank overhead, from which it flows to the various parts of the turbine through pipes equipped with sight flow fittings at convenient points.

Turbine speed is accurately indicated by a vibration type tachometer, mounted on the top of the turbine as shown. All necessary gages, tools and the like are provided for the convenience of the operator.

At one side of the engine room is mounted the new 7-panel switchboard. Three generator panels carry oil switches, rheostats, voltmeters and ammeters, a synchroscope, an indicating frequency meter and a voltage regulator. Two laundry feeder panels carry oil switches and a watt-hour meter and indicating power factor meter on the panels show the total plant output. A panel provided for the elevator and dry tumbler circuits and other small power circuits carries air break circuit breakers. For lighting circuits in the plant, power is stepped down from 240 to 115 v. by a bank of three transformers of 25 kv.a. each and distributed from the 7th panel. Power for lighting may also be taken from the local power company's lines outside.

Engineering design of the mechanical equipment of this plant was by B. M. Baxter & Co.; the boiler house building was designed by Christian, Schwarzenberg & Gaede. E. E. Harr is superintendent of the Independent Towel Supply Co. and E. E. Perry is chief engineer. We are indebted to the above for data and co-operation in preparing this article.

Synchronous Motor-Generators for Edison Systems

The motor-generator set can be designed for any voltage range which may be required, and it has the added advantage of great stability and also that, as the alternating-current and direct-current machines are electrically separate, any disturbance is not transmitted directly from one system to the other.

Most of the motor-generator sets which have been supplied for Edison service during the past few years have been equipped with a differential series-field winding on the direct-current generator, which makes this machine inherently load limiting.

The synchronous motor-generator set also can be designed so as to supply a certain amount of leading kilovolt-amperes to the system, and can therefore be used for the purpose of raising the system power-factor, whereas the synchronous converter is limited to operation at or near unity power-factor.

The load-limiting characteristics of the direct-current generator allow it to be connected to the bus without overload protection on the direct-current end, therefore the maximum service can be obtained without interruption.

In anticipation of improvements during 1926 at Station "B" of the San Diego Consolidated Gas & Elec. Co., work on a new circulating water tunnel was begun in 1925 to care for the extra condenser capacity needed by the addition of a 20,000-hp. turbine bringing the capacity of the station to 47,000 hp. This tunnel is 1300 ft. long and the open-cut pneumatic caisson method was used in installing it.

Turbine Efficiencies and Condenser Conditions

INSTALLATIONS SHOULD BE CONSIDERED AS A WHOLE AND PARTIAL LOAD CONDITIONS CAREFULLY INVESTIGATED

TURBINE EFFICIENCIES are reflected not only from the coal pile but from the condensing equipment as well. Inefficient machines may increase the first cost and operating expense of auxiliaries to such an extent that the apparent saving in first cost may not only disappear but become an actual detriment.

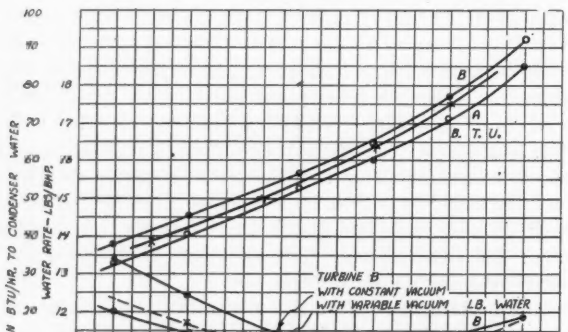


FIG. 1. TYPICAL WATER RATE CURVES OF TWO TURBINES WITH TOTAL HEAT DELIVERED TO CONDENSER COOLING WATER

Efficiencies of turbines have by no means reached the maximum value possible but the increment of increase per unit of cost is so small that no startling increases are probable. Refinements in design add materially to the first cost so that commercial efficiencies are determined by the manufacturer largely on an economic basis. It is but natural, therefore, that considerable variation will appear in the water rates of the several machines and the problem is to determine the one which, in a particular installation, will pay the biggest return on the entire investment.

When comparing two or more turbines on the basis of water rates, the difference in steam consumption is easily calculated for any given load condition. Typical guarantees for two machines are given in Fig. 1., for 150 lb. gage, 50 deg. superheat steam, the vacuum remaining constant at 27 in. referred to a 30 in. barometer. The total steam consumption curves, or Willan's line of the two turbines can be easily calculated and when considered with the cost of steam, first cost, operating expense and depreciation of the turbines gives a fairly reliable basis of selection, if other equipment be neglected.

AVAILABLE HEAT IS DISSIPATED IN FOUR WAYS

When, however, condensing equipment is included, both the total flow of steam and the heat content per unit weight must be considered. When steam passes the throttle, the available heat is dissipated in one of four ways: as useful work available at the coupling; as mechanical losses of the governor, oil pumps, valve gear, bearings and water seal; as radiation and convection heat losses; or as windage and blade losses.

Heat converted into work can be calculated from the water rate of the turbine at the desired load. One horsepower is equivalent to 2545 B.t.u. per hr. Dividing this by the water rate of the machine gives the heat actually converted into work for each pound of steam used. Mathematically this may be expressed as $h = 2545 \div R$, where h = heat in B.t.u. converted into work from each pound of steam and R = water rate of turbine in pounds per brake horsepower hour. Generator efficiencies must be considered when dealing with direct connected units.

Mechanical losses are more indefinite, any expression being more or less arbitrary. To determine the approximate states mechanical losses as a per cent of normal rating the following rule will serve: Divide the

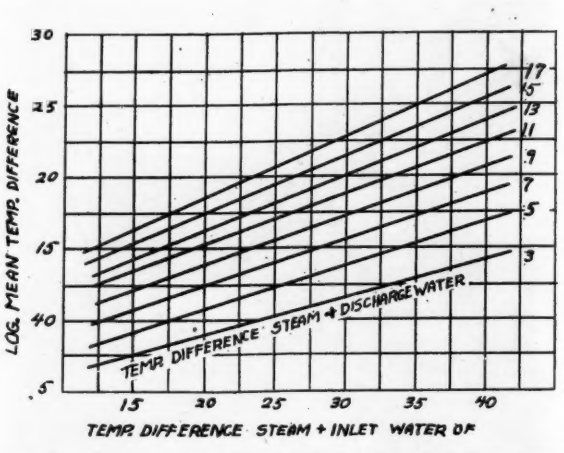


FIG. 2. CHART FOR DETERMINING THE LOGARITHMETIC MEAN TEMPERATURE DIFFERENCE FOR VARIOUS CONDENSER CONDITIONS

horsepower rating by 1340, extract the square root of the quotient, then divide 4 by this root and the result will be the mechanical losses expressed as a percentage. In the case of the 8500-hp. machine, being considered, these losses amount to about 1.6 per cent.

In the larger units radiation and convection losses considered as a percentage are small, casings are well lagged and the large radiating surfaces of the machines are at low pressures and temperatures. Considered together, the combined radiation and mechanical losses will, except for unusual conditions, come within two per cent on machines of the size being considered. The effect of these losses is the same as the abstraction of heat for work and they do not again appear. As both are mechanical, not steam losses, they should be expressed as a certain number of horsepower. Furthermore, they are dependent on speed and practically constant regardless of load.

Windage and blading losses are by far the largest but, as they occur entirely within the turbine, they are reconverted into heat and appear in the turbine exhaust to be carried away by the condenser water.

The condenser then is called upon to handle the total

heat of the entering steam minus the work, mechanical heat losses and heat in the condensate above 32 deg. F. In this case the vacuum temperature is 115 deg. F. and if the condensate is assumed to be within 5 deg. F. of this value, the heat so carried away amounts to 78 B.t.u. per lb. Then $A = W (H - h - c) - 8500 \times 0.02 \times 2542$, where A is the total heat to be carried away by condensing water, W is the total weight of steam used, H is the total heat in one pound of the entering steam and c is the heat in B.t.u. above 32 deg. F. in each pound of condensate. The last expression in the equation reduces to 430,000 B.t.u.; it is the mechanical and radiation losses taken as two per cent of the rating. It is thus apparent that an inefficient turbine not only will use more steam but will extract less heat from each pound of steam used. Substituting specific values for H and c, the expression above will be reduced to

$$A = W(1147 - h) - 430{,}000$$

which is the basis upon which the total heat curves in Fig. 1 were drawn.

This heat is absorbed by the circulating water, the quantity of which can be found from the equation

$$Q = A \div 500\ D$$

where Q is the circulating water in gallons per minute and D is the temperature rise in degrees. If, with a 27-in. vacuum and 90-deg. water, the temperature rise is taken as 15, the outgoing water will be within 10 deg. of the vacuum temperature, a good commercial value. Circulating water requirements of turbines A and B amount to 11,300 and 12,250 g.p.m. respectively at the maximum load of 8500 hp. Sometimes temperatures and capacities are fixed so that quantities and surface requirements must be changed accordingly. Discharge water may at times be brought to within 5 deg., or even less, of the vacuum temperature but a slight air leak or coating of the tubes will reduce the surface efficiency and make satisfactory operation questionable.

In addition to its effect on the quantity of circulating water necessary, the temperature rise of the water and its relation to the vacuum temperature determines, to a large extent, the tube surface necessary. With a predetermined quantity of heat per hour the condenser surface necessary will be $A \div TU$, where U is equal to the heat transference in B.t.u. per square foot per degree temperature difference and T is equal to the mean temperature difference.

Arithmetical Temperature Difference Satisfactory for Small Temperature Differences

This mean temperature difference is a function of the vacuum temperature as well as of the entrance and discharge temperatures of the water. For exact determinations the logarithmic mean given graphically in Fig. 2 should be used, although the determining factors of temperatures, proportional mixtures of non-condensable vapors with corresponding ratios of heat transference are difficult to determine accurately. Arithmetical mean temperature difference is ordinarily used. The arithmetical mean temperature difference is $T = T_s - [(T_1 + T_2) \div 2]$, where T_s is equal to the vacuum temperature and T_1 and T_2 the entrance and discharge water temperatures respectively.

Values of U may run up as high as 600 or 700 with new, clean tubes but this value decreases rapidly with service and 450 is a good commercial value. On this basis, the surface required for maximum rating of the turbines would be 10,800 and 11,700 sq. ft. respectively for turbines A and B. The value of the coefficient varies with the velocity of water flow through the tubes and also with the temperature difference. Figure 3 shows the variation for velocities up to about 16 ft. per sec., the arithmetical mean temperature difference varying from about 135 to 150 deg. F. This temperature difference is much above that of ordinary condenser practice but serves to illustrate the importance of proper water velocities in the tubes.

Condenser and Auxiliaries Require Complete Investigation

Differences in the equipment necessary for the several machines will usually be small, perhaps the difference between a 12 and 14-in. pump, between a 75 and

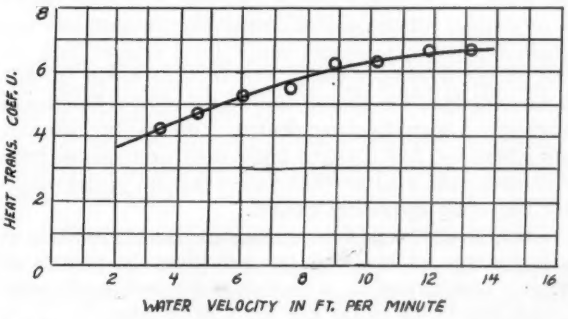


FIG. 3. SHOWING THE EFFECT OF WATER VELOCITY ON THE COEFFICIENT OF HEAT TRANSFERENCE OF CONDENSER TUBES

100-hp. motor, or a thousand feet of condensing surface. These small differences may or may not be cumulative and the selection of the condensing equipment and auxiliaries is not ordinarily as easy or as definite a proposition as selecting the prime mover.

Uncertainty regarding the unit heat transference under service conditions has, until recent years, been the determining factor in allowing considerable leeway in condenser practice.

Excavating and installation costs for large units now necessary with modern turbines, the difficulty of handling and casting large sections and the chance for air leakage around joints have been deciding factors in directing attention to condenser design and have resulted in radical condenser changes. Improved design and cleaning methods have raised the average heat transference considerably with corresponding reduction in surface.

Slight Leeway Sometimes Allowed in Condenser Calculations

Mechanical and radiation losses of the turbine are ordinarily neglected in condenser design to give a slight leeway to calculated results. Unit heat transference varies with the velocity of flow through the tubes and with the circulating water temperature so that in the absence of specific data exact determinations are impossible. As with any other piece of equipment, it is unwise to attempt to buy guarantees and hold the manufacturer responsible for details beyond his control, although a reputable manufacturer will not guarantee

values beyond those which past practice has proved attainable.

As the load on the turbine decreases, the heat flow to the condenser also decreases and the vacuum will naturally increase. This increase is of paramount importance to the turbine manufacturer, as it enables him to better his partial load guarantees considerably.

When bidding on a combined turbine and condenser unit, the manufacturer can take advantage of the increased vacuum at partial load and show a decided advantage over the manufacturer who is bidding on a turbine alone and must confine his guarantees to constant vacuum at all loads.

Condenser Guarantees Should Cover Partial Loads

For this reason a condenser guarantee is not complete with only full load conditions any more than the turbine guarantee would be with the water rate given at only one point. The effect of the two pieces of equipment is, of course, reciprocal; an increase in vacuum will decrease the water rate and result in a smaller flow of heat to the condenser which will in turn result in still higher vacuum, the action continuing until a balance is reached. A manufacturer dealing with one turbine and one condenser has a slight advantage over competitors who must deal with average values instead of determining the exact operating figures.

Of necessity, condenser guarantees cannot be made as a percentage of the load but are given in pounds of steam. Guarantees for a condenser for turbine B were:

100,000 lb. of steam per hr. 3.00 in. abs.
75,000 lb. of steam per hr. 2.45 in. abs.
50,000 lb. of steam per hr. 2.00 in. abs.

On the basis of this variable vacuum the water rate of the turbine was changed, as shown by the dotted line in Fig. 1.

Comparing the three water rate curves brings out the necessity for comparing equipment as a whole rather than the individual machines. Performance of turbine B offered by a manufacturer complete with a condenser would be represented by the dotted curve, much to the disadvantage of turbine A whose performance is given by the water rate on the basis of a constant vacuum.

Service Record of Spray Pond Important*

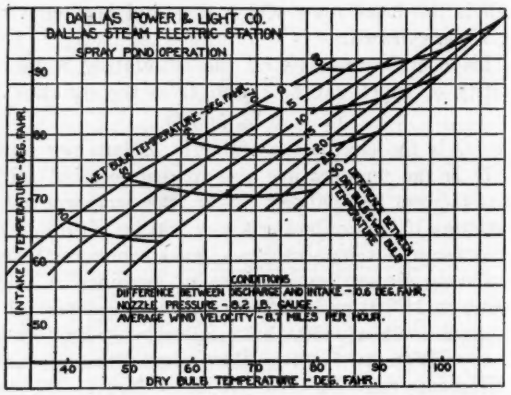
Wet Bulb Temperature Controlling Factor But Chemical Concentration, Driftage and Vegetable Growth Must Be Considered

SPRAY POND operation, still important in many sections of the country, is a problem upon which actual data is comparatively scarce. Practically all information available deals with theoretical values so that data collected by the Dallas Power & Light Company over a period of a year are particularly interesting.

Hourly readings of dry and wet bulb temperature, temperature of water before and after spraying, pressure on nozzles, load on plant, average wind velocity and direction, and state of weather were recorded.

In order to obtain values which would represent stable conditions, the readings from 8 a. m. to 4 p. m. were averaged for each day and these values used in making the analyses. Of several methods used, the most consistent results were obtained from the assumption that the wet bulb temperature is the major factor in determining the intake temperature. This is also borne out by theoretical considerations. The dry bulb temperature has the next greatest influence, but it is slight compared with that of the wet bulb. It was impossible to establish definitely the effect of the following factors upon intake temperatures: difference between temperature of water before and after spraying, pressure on nozzles, wind velocity and weather conditions.

It is felt, however, that the load upon the pond, represented by the difference in temperature of the water before and after spraying, has some effect upon the intake temperature, but within the limits represented by the data taken this effect was small compared to the effect of the wet and dry bulb temperatures.



CURVES CONSTRUCTED FROM OBSERVED DATA SHOW THE EFFECT OF WET AND DRY BULB TEMPERATURES ON SPRAY POND OPERATION

Year's Reports Combined on One Chart

Curves worked up from the data collected are given in the accompanying figures showing the intake temperatures which may be expected under various temperatures.

This pond has a total capacity of 78,760 g.p.m. and serves the entire circulating water for the Dallas plant with capacity of 36,000 kw. Three circulating pumps are used with a normal discharge pressure of 18 lb., sufficient to force the water through the condensers and spray it through the nozzles maintaining a pressure of from 6 to 9 lb.

Loss of water from spraying is roughly one per cent of the amount of water sprayed, normal requirements for make-up being roughly 500,000 gal. a day supplied from artesian wells. The water is high in sodium carbonate with small amounts of calcium and as a result of evaporation, water in the pond becomes highly concentrated. This concentration is controlled, to a certain extent, by feeding in an excess amount of make-up water and allowing some of the pond water to run over the spillway.

With the high concentration of sodium and calcium in the water, trouble from scale formation in the con-

*Taken from N. E. L. A. Prime Mover's Committee Report on Condensing Equipment.

denser tubes was experienced. This condition is minimized by the use of rubber plugs cleaning each condenser regularly once a week. In this way the scale is removed from the tubes before it hardens but if scale is allowed to build up for a period of two months, it cannot be removed except by the use of acid or turbining.

Copper Sulphate Prevents Vegetable Growth

In order to prevent fungus growth in the summer time, the water is treated with copper sulphate, by placing approximately 25 lb. of the chemical in a burlap bag and hanging it in the water just ahead of the intake. About 25 lb. of sulphate is used every two weeks.

Driftage is a feature which is met with in spray pond operation and during times of cold or damp weather is excessive even with light winds. At the Dallas plant there is a 60-kv. outdoor switching structure located approximately 120 yd. south of the spray pond and serious difficulty arises from the coating of the insulators with salts in the water carried through the air. The electrical equipment is elevated on a concrete structure about 20 ft. above the ground and, for this reason, it is impracticable to construct a barrier between it and the pond without getting into an expensive piece of construction. At least 300 yd. separation should be allowed between the pond and outdoor high voltage electrical equipment.

Orifice Tests for Rotative Dry Vacuum Pump

Calibrated Orifices Simplify Testing and Permit Securing Pump Characteristic Curve for Checking Performance. By Robert R. Walden

IN MODERN POWER PLANTS the various auxiliary apparatus is tested at regular periods in order to ascertain whether the apparatus in question is up to capacity and is in good condition and can be relied upon.

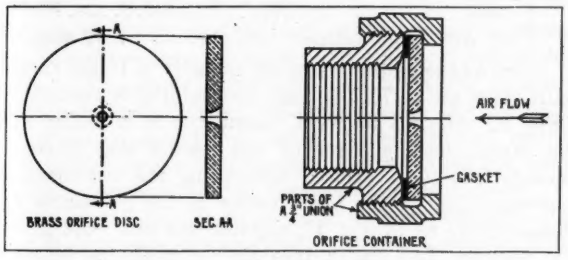


FIG. 1. THE ORIFICE MAY BE CONVENIENTLY HELD IN A UNION

The failure of a single part may cause serious damage or if not up to capacity may cause a loss to the company due to inefficiency. In this article will be described the method employed by a well known concern in testing its rotative dry vacuum pumps.

The pump tested was a motor-driven Westinghouse Leblanc d. v. pump, where the hurling water was taken into the impeller and thrown out in slugs, each slug taking a particle of air with it, thus, creating a vacuum on the condenser. The water containing the air was discharged through a venturi throat.

Usual practice is to place a valve in the air line between the condenser and the air connection to the pump. Between this valve and the pump two holes are drilled and tapped, one for a ⅛-in. pipe and the other for a ¾-in. pipe, each being fitted with a nipple and valve. When testing, an orifice is connected to one and a mercury column to the other. The apparatus holding the orifice can be made from a ¾-in. union as shown in Fig. 1 but care must be taken to see that the orifice is inserted in right manner.

The orifice disks are six in number and each contains an orifice having one of the following diameters: ⅛, $\frac{5}{16}$, ¼, $\frac{7}{16}$, ⅜ or $\frac{7}{16}$ in.

These orifices when made have to be calibrated which can be done usually at any engineering college near the plant or by sending them to the Bureau of Standards. The cost of this work is small and when once accomplished need not be repeated. A characteristic orifice calibration curve is shown in Fig. 2 and is the one used at this plant for testing.

Apparatus required to make this test consists of the orifices, two thermometers, mercury column, tachometer and a barometer.

Testing Is Done by the Following Method

Close the valve between the dry vacuum pump and condenser. Take readings of the room, air temperature,

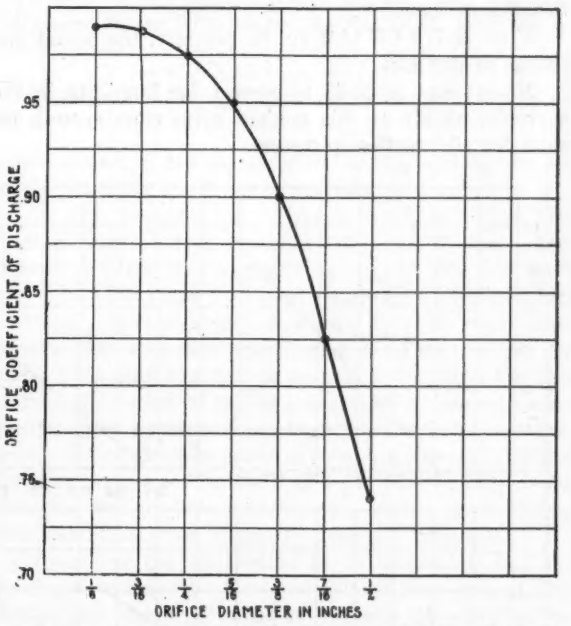


FIG. 2. CALIBRATION ONCE MADE IS PERMANENT AND RELIABLE

mercury column, barometer, speed of the pump, hurling water temperature and hurling water suction for each size of orifice. The hurling water vacuum is taken from a test gage installed in the hurling water suction line and which is usually already connected for ordinary operation.

The test is based on the following theory of Boyles and Charles Laws:

$$PV = MRT$$

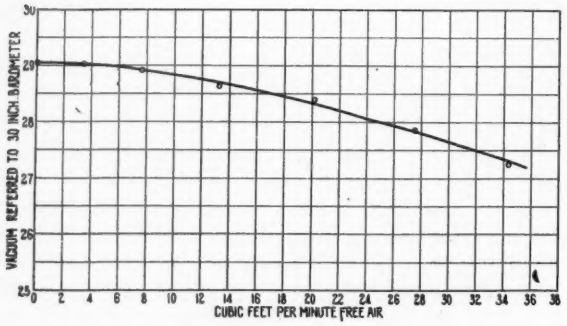


FIG. 4. THIS RECORD OF CAPACITY TESTS SERVES AS A STANDARD FOR CHECKING DAILY PERFORMANCE

Where M = lb. of air; P = pressure in lb. per sq. ft.; V = volume of air in cu. ft.; R = 53.34.

Now when air expands below the critical pressure:

$$M_1 = 0.53\ FP_1 \div \sqrt{T}$$

Where M_1 = lb. of air per second; P_1 = pressure in lb. per sq. in.; F = area in sq. in.; T = absolute air temperature.

Now by combining the two formulas, we obtain the theoretical volume of dry air passing through an orifice of F sq. in. per min. with a temperature T or

$$P \times 144 \times V = 0.53\ FP_1 \times 53.34 \times T \times 60 \div \sqrt{T}$$

$$V = 0.53 \times 53.34 \times 60 \times FT \div (144 \sqrt{T})$$

$V = 11.779\ F\sqrt{T}$ cu. ft. of dry air per min. the theoretical discharge.

Now inserting C the co-efficient of discharge in the formula we have.

$V = 11.779\ CF \sqrt{T}$ cu. ft. per min. the actual discharge of dry air.

No attempt is made to correct for humidity in the surrounding air as this method gives close enough results for all practical purposes.

Handy curves may now be made up similar to Fig. 3 for use with all future tests using these same orifices, thus saving much time in calculating. These curves may be used on any orifices of this type and size with a probable error of only 2 per cent, this error being due to the difference in the orifice co-efficients only.

Following is a sample record of a test taken on the above-mentioned pump with the curve of Fig. 3 used for finding the cubic feet per minute free air.

SAMPLE TEST RECORD

Westinghouse Leblanc Air Pump, Size 18, Motor-Driven.

March 1, 1926.

Orifice	Observed Vacuum	Vacuum Ref. to 30 in. Bar	Cu. Ft. Min. Free Air
Valve Shut	29.1	29.04	.....
1/8	29.08	29.02	3.391
3/16	28.98	28.92	7.545
1/4	28.70	28.64	13.24
5/16	28.45	28.39	20.16
3/8	27.90	27.84	27.52
7/16	27.3	27.24	34.33

Hurling Water Vacuum.....6 in.
Hurling Water Temperature.....78 deg. F.
Barometer .....30.06 in.
R.p.m. 755
Free Air Temperature.....92 deg.

Now as the guarantee pump capacity is 12 cu. ft. per min., free air at 70 deg. and maintaining a vacuum of 28½ in. referred to 30-in. barometer, it is easily seen by examining the curve of test results that it corresponds to a ¼-in. orifice. Correcting the test capacity corresponding to the ¼-in. orifice to the guarantee air temperature of 70 deg. F., the test will now read 28.64-in. vacuum, 12.7 cu. ft. free air per min., the free air temperature being 70 deg. F. This correction to the

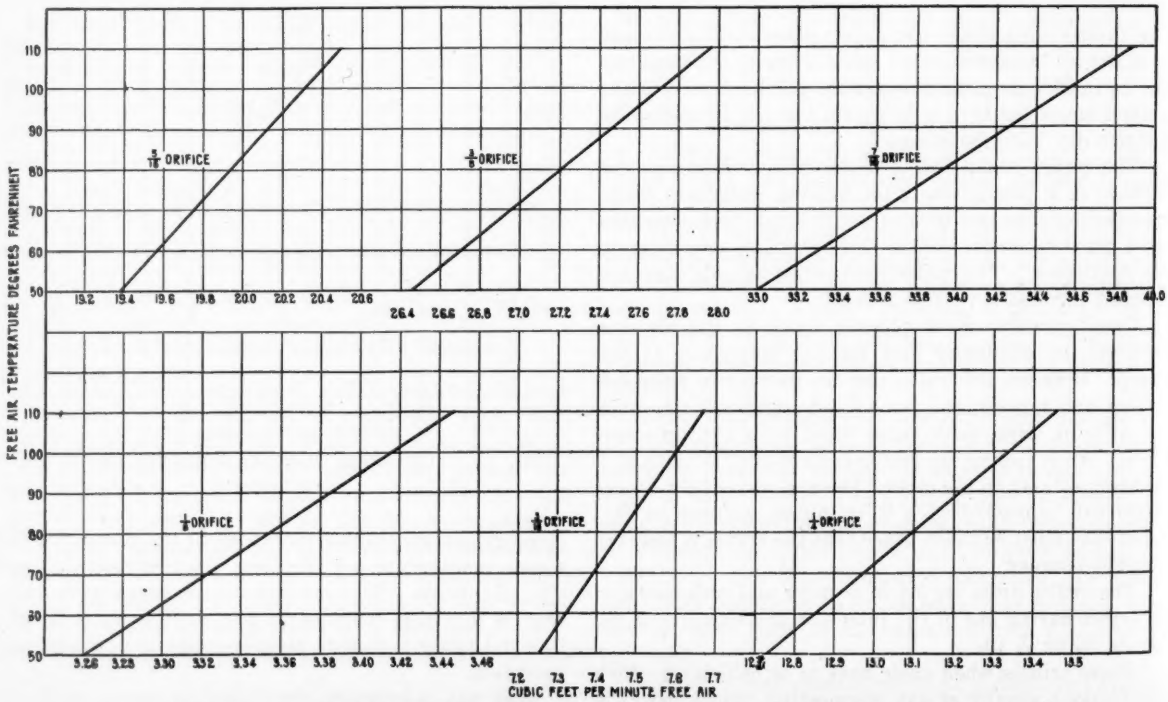


FIG. 3. DISCHARGE CURVES FOR THE ORIFICES FACILITATE WORKING UP BEST DATA

guarantee temperature is made as follows. The theory being:

$P_g V_g \div T_g = P_t V_t \div T_t$, where $P_g = P_t$ or $V_g = V_t$ $(460 + T_g) \div (460 + T_t) = 13.24\ (460 + 70) \div (460 + 92) = 12.7$ cu. ft. P, V and T being pressure, volume and temperature respectively; G denoting guarantee and T test conditions.

From the curve of test results, Fig. 4, we have:

	Capacity	Vacuum	Free Air Temp.
Test Conditions.....	12.7 c.f.m.	28.64 in.	70 deg.
Guarantee	12.5 c.f.m.	28.5 in.	70 deg.

From which we see that the pump is doing 1.6 per cent better than guarantee in capacity and 0.5 per cent better than guarantee in vacuum and we have obtained its characteristic capacity curve.

Many things may cause a pump of this type to fail, among which are worn vanes and stoppages in the vanes, impeller or suction line; any of these will affect the characteristic curve causing it to drop, thus informing the engineer that the pump needs attention.

The writer has used these orifices and larger ones in testing small air compressors to obtain their capacity curves and has found them to be very satisfactory.

Calculating Flue Gas Losses*

FORMULA FOR FIGURING MAXIMUM CO_2 LEADS TO METHODS OF CALCULATING FLUE GAS LOSSES. BY ANDREW A. BATO†

AS A RULE, combustion engineers do not realize the possibility of calculating flue gas losses when only the analysis and gas temperature, and not the analysis of the fuel, are known. This method saves the cost of time and labor in making an ultimate analysis.

Since the proper operation of any fuel burning device can be judged principally by the analysis of the flue gas and determining whether the amount of excess air is greater than necessary and whether combustible gases are escaping unburned, it is necessary to know what constitutes perfect combustion with any fuel.

When burning a fuel containing carbon and hydrogen as combustible constituents, and no other gas, combustible or incombustible, provided the exact amount of pure oygen necessary to give perfect combustion to CO_2 and H_2O is used and provided no CO is generated, three times as much oxygen will be used to burn a pound of hydrogen as will be used to burn a pound of carbon; because to burn 12 lb. of carbon, 32 lb. of oxygen are required, corresponding to a ratio of 3:8, whereas, for every pound of hydrogen, 8 lb. of oxygen will be needed, the ratio being 1:8. If, therefore, the ratio of the amounts of carbon and hydrogen contained in the fuel are known, it will be possible to determine what part of the oxygen used will change into CO_2, and what part of it will become water and practically disappear from the volumetric analysis.

FORMULA DEVELOPED FOR MAXIMUM CO_2

If an ultimate analysis of the fuel is given, the maximum percentage of CO_2 obtainable with no excess air and perfect combustion, may be found by the following formula:

$$\text{Maximum } CO_2 = \frac{8.86}{0.422 + \frac{h - o/8}{c + 0.37\,s}}$$

where h, c, o and s are the respective percentages by weight of hydrogen, carbon, oxygen and sulphur.

It has been shown that if carbon is burned in an excessive amount of air the sum of CO_2 and O in the flue gases will always be constant, namely, 21 per cent. This, however, will not be the case when a fuel is burned containing hydrogen and carbon. When there is no excess air and the combustion is perfect, the CO_2 content will be equal to $CO_{2\,(max.)}$. If to a flue gas having $CO_2 = CO_{2\,(max.)}$ air is added from any source whatsoever (through grate, burner, or cracks in the brickwork of the boiler), the sum $CO_2 + O_2$ will be greater than $CO_{2\,(max.)}$, but less than 21. This sum, however, will approach 21 as more and more air is added to the gas, 21 corresponding to an infinite amount of air mixed with the products of perfect combustion. There will always be, however, a definite relation between the contents of CO_2 and O_2 of the flue gases on one side, and the $CO_{2\,(max.)}$ of the fuel burned on the other, as given in the equation:

$$CO_{2\,(max.)} = \frac{21\,k}{21 - o_2} \quad \ldots\ldots\ldots 1$$

where k and o_2 are the amounts of CO_2 and O_2 respectively found in the flue gas analysis.

If the products of combustion of any fuel are analyzed and the percentages CO_2 and O_2 are determined, it is possible to find $CO_{2\,(max.)}$ of this fuel with the aid of Equation 1 without requiring a chemical fuel analysis. It is necessary, however, that the combustion be complete and that no unburnt gases escape into the flue. This condition can be secured by burning the fuel during the period of taking one sample of gas with such an excessive amount of air that there will be no possibility for combustile gases to escape unburned. When burning coal, a content of 5 to 6 per cent of CO_2 in the flue gas will provide a sufficient security for fulfilling this condition even in poorly designed furnaces.

Assuming the combustion to be incomplete but the hydrogen contained in the fuel to have been burned perfectly and the flue gases to contain CO only as an unburned combustible gas, a connection can be found between the percentages of O_2, CO, CO_2, and the $CO_{2\,(max.)}$, as in the case of perfect combustion. Keeping the symbols as used above and using k_m for the percentage of carbon monoxide, the formula becomes—

$$CO_{2\,(max.)} = \frac{21\,(k + k_m)}{21 - o_2 + 0.395\,k_m} \quad \ldots\ldots 1a$$

It can be readily seen that for the case of a complete combustion, that is, if k_m is made equal to zero, Formula 1 will result.

*Abstract of a paper read before the A. S. M. E., New York, February 24, 1926.

†Mechanical Designer, Public Service Production Co.

Charts Are Used to Calculate Losses

After determining the maximum CO_2, the chart shown in Fig. 1 may be used to determine the flue gas losses if combustion is complete. If CO is present, Fig. 2 may be used.

On the diagram of Fig. 1 a row of lines shows the amount of excess air, E, mixed with the flue gases generated by perfect combustion, the quantity of which is given as a multiple of the air necessary for perfect combustion. Thus line E, equaling 0.6, connects all points which represent combustion with an amount of air exceeding the amount necessary for perfect combustion by 60 per cent. For the example plotted in the diagram, E equals o.3. Line E equaling 0.0, connects points with no excess air.

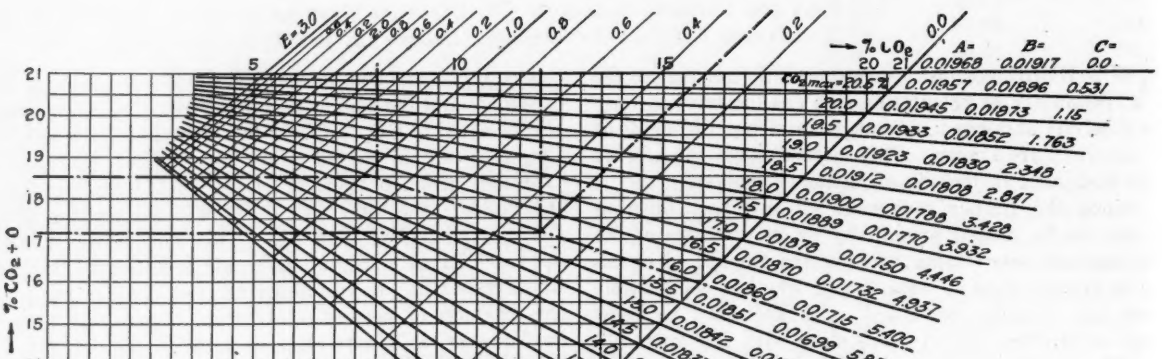


FIG. 1. AFTER CALCULATING MAXIMUM CO_2, LOSSES MAY BE DETERMINED BY USE OF THIS CHART, IF NO CO IS PRESENT

A formula for E is given, using symbols similar to those in Equation 1:

$$E = \frac{(CO_{2\ (max.)} - k)\ 79}{k\ (100 - CO_{2\ (max.)})} \quad \ldots\ldots\ldots 2$$

which is a handy formula for drawing lines of equal E.

The E lines give a general view of the significance of the CO_2 content when judging the results obtained in burning various fuels. Thus 15.3 per cent CO_2 in the flue gas produced through the combustion of anthracite having a $CO_{2\ (max.)}$ equal to 20.0 per cent means 30 per cent excess air, the same percentage of CO_2 in the gases of a high-volatile coal with $CO_{2\ (max.)}$ equal to 18.5 per cent means only 20 per cent excess air.

It can readily be seen that CO is generated in a great majority of cases when air is present in an excessive amount, proved that an imperfect and incomplete combustion is due, rather to poor mixing of the gases and cooling below the point of ignition before ending combustion, than to lack of air.

In actual practice it will be extremely rare to find a gas analysis corresponding to a point in the region of the e lines; it may be found in an oil furnace with a highly reducing flame where the amount of air purposely is kept low, or momentarily in the exhaust gases of a crude oil engine when the air is throttled out of proportion through irregular working of the governor.

In the case of incomplete combustion it is not the carbon monoxide only that may escape unburned, but also some hydrogen and hydrocarbons. This will result in a flue gas analysis giving a higher content of CO_2 than $CO_{2\ (max.)}$.

Since the escaping of unburned CO results in a lower percentage of CO_2 and, on the other hand, unburned hydrogen or hydrocarbons cause a higher content of CO_2, there must be a case in which both kinds of gases escape unburned in such a proportion that the effect of their presence keeps the balance by giving the proper amount of $CO_{2\ (max.)}$ as a result, or, if air is mixed with the gases, Fig. 2 will give a value of CO equal to 0.0 for the amount of CO_2 and $CO_2 + O_2$ found by the analysis, although not only unburned CO is present, but hydrocarbons as well. For example, if all the hydrogen of the heavy oil mentioned above should be present in the form of CH_4, a combination is theoretically possible with 3.05 per cent CH_4 and 1.58 per cent CO giving 16.00 per cent of CO_2, which is the proper amount. From the theoretical standpoint this would make the use of Fig. 2 impossible for purposes of checking whether or not CO is present, but experience shows that such conditions do not exist to any appreciable degree in stoker fired furnaces with a uniform state of combustion, the amount of escaping hydrogen and hydrocarbons representing only a negligible fraction of the carbon monoxide as long as the latter does not exceed the usual low limit, and even then this amount does not rise above 30 per cent of the CO. On the other hand, during moments of irregular fuel supply, most surprising analyses are often obtained.

In the case of an overfeed stoker, if a great amount

of green fuel is suddenly pushed over the incandescent fuel bed, or an avalanche takes place, the result obtained from the diagram for CO may even be negative. The reason for it is the fact that when coking some kinds of coal the first products of distillation contain a high percentage of CO_2, which mixes with the flue gas without a corresponding amount of nitrogen, as it is not a product of combustion with air, and results in too high values for $CO_2 + O_2$. As shown by Fig. 2 this would result in false high values for maximum CO_2 and correspondingly low ones for CO. On the other hand, if the fire is banked for a long time, the fuel on the grate will contain less hydrogen in proportion to the carbon than the green fuel, as most of this gas was distilled with the volatile part of the fuel. As a result of long experience it may be stated, however, that seven to eight out of ten analyses show a perfect accordance with the diagram, and only two to three a discrepancy equal to 0.1 to 0.3 per cent.

After the flue gas analysis has been checked with the aid of the diagrams, it may be used, together with the readings of thermometers used for measuring the temperature of the flue gas, T, and that of the air used for combustion, t, to calculate the percentage of the heating value of fuel lost in the sensible heat of the departing gases, without knowing the heating value of the fuel, and to make a heat balance without an ultimate analysis of the fuel.

If one pound of carbon is burned with zero excess air, and the combustion is perfect, 11.52 lb. of air are used, producing 3.67 lb. of CO_2 and 8.85 lb. of N_2, and giving, when multiplied with the corresponding values of their specific heats, a total heat capacity of 2.864 B.t.u. per deg. F. For calculations on a percentage basis, multiply by 100, getting for carbon $2.864 \times 100 \div 14{,}540 = 0.01968$ per cent. This number, multiplied by the difference T — t, gives the heat loss in per cent of the heating value of the fuel, and therefore represents the loss per 100 B.t.u. generated per deg. F. rise of temperature of the flue gases above the temperature of air used for combustion.

Using the lower heating value of hydrogen, the loss per 100 B.t.u. and 1 deg. F. is practically the same as for carbon, namely, 0.01945, and remains, therefore, the same for mixtures of the two in any proportion, thus greatly facilitating the calculation. In this country, however, the use of the higher heating value being established, the loss per 100 B.t.u. and 1 deg. F. for various mixtures of carbon and hydrogen, without the loss due to the heat of vaporization, A, must be computed according to the proportion of carbon and hydrogen in the fuel. This proportion, however, determines the $CO_{2(max.)}$ of the fuel and is determined by it, for which reason the values for factor A could be marked on Fig. 1 on the lines for each value of $CO_{2(max.)}$, preferably numerically. This method makes them more readily usable than a representation by a curve. Interpolation, on the other hand can be performed through numerical calculation.

The losses carried away in the gases through excess air can be computed in a similar way. The amount of air used to produce 1 B.t.u. in burning carbon is somewhat greater than the amount used in burning hydrogen. For this reason, if both elements are burned with the amount of air corresponding to double that necessary, or when the excess air equals the amount that was actually used for combustion, the loss for the same amount of heat generated will be somewhat less if the heat is generated by burning hydrogen than if it is generated by burning carbon, provided T — t is the same in both cases.

For E = 1.0, the loss per 100 B.t.u. and 1 deg. F. will be 0.01926 when burning carbon, and 0.01348 when burning hydrogen. For various mixtures of the two this quantity, called B, is shown in Fig. 1 on the corresponding lines of $CO_{2\ (max.)}$.

The loss due to the heat of vaporization of the moisture formed in burning the hydrogen will naturally increase with the increase in percentage of hydrogen in relation to that of carbon, and will thereby increase with

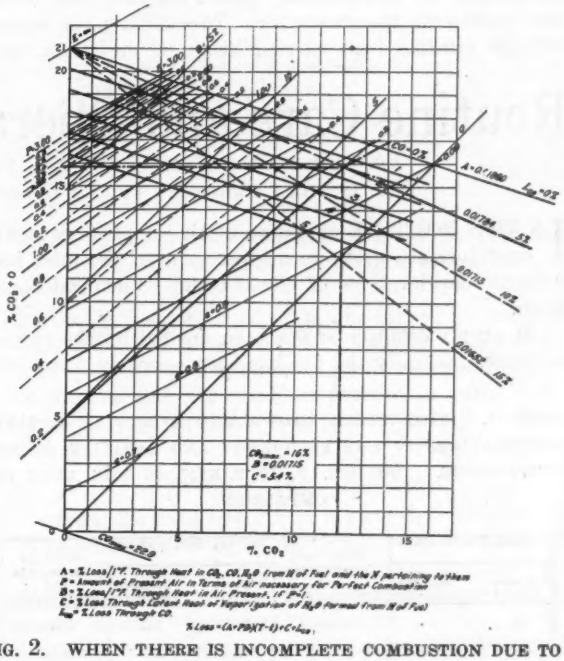

% CO + O
% CO₂
A = % Loss[/1°F. Through Heat in CO₂, CO, H₂O from H of Fuel and the N pertaining to them
B = Amount of Present Air in Terms of air necessary for Perfect Combustion
B = % Loss[/1°F. Through Heat in Air Present, 1F. ps].
C = % Loss Through Latent Heat of Vaporization of H₂O formed from H of Fuel
% Loss = (A+PBNT-t)+C+i

FIG. 2. WHEN THERE IS INCOMPLETE COMBUSTION DUE TO CO, LOSSES MAY BE DETERMINED BY THIS DIAGRAM

the decrease of $CO_{2\ (max.)}$ as the latter is given through the quotient H/C. It can be expressed as a fraction or percentage of the heat value of the mixture or compound of carbon and hydrogen the same as the losses given above for heating the gases and the vapor, but it will be independent of T — t. These values are given in Fig. 1 as factor C.

With the aid of a flue gas analysis, in the case of complete combustion, the losses due to heat carried away in the flue gases for dry fuel can be computed with the aid of the diagram Fig. 2, and the simple formula:

Per cent of loss = $(A + EB)\ (T - t) + C$

Example. In the case marked on Fig. 1, $CO_2 = 12$ per cent, $CO_2 + O_2 = 17.2$ per cent, E = 0.3 per cent, and the percentage of loss = $(0.01860 + 0.3 \times 0.01715)\ (T - t) + 5.4$.

In Fig. 2 lines are drawn to make possible the calculation of losses in cases in which the gases contain CO. The value of A will depend on the amount of carbon burned to CO in relation to the amount burned to CO_2. As one pound of carbon, when burned, gives just as

many cubic feet of CO_2 as it would have given of CO, if burned to the latter, the ratio (CO/CO_2) of the two gases present will give the ratio of the two respective quantities of carbon burned to these gases. The lines of constant A will, therefore, be lines along which the ratios of CO to CO_2 will also be constant.

The amount of heat carried away in the air mixed with the gases will not be contained to the full extent in the excess air if CO is present, as some of this heat will be found in the air that is present in the gases, though not excess air, as it was destined to serve for the combustion of CO. In other words, the air present in the gases consists of two parts: one part of it would be just sufficient to burn the whole contents of CO to CO_2, provided other conditions would be favorable to it; that is, if the gases were heated again to the ignition temperature of CO and properly mixed together; the other part represents the excess air. To calculate the losses through sensible heat carried away in the gases, the total amount of air present in the gases must be taken into consideration. The latter is represented in Fig. 2 by lines marked P running through the points of intersection made by lines E of the same value, and the line CO equals O, as in the case when there is no CO in the gases the excess air is equal to the total air present.

The loss $L_{(co)}$, due to the fact that some of the carbon was burned to CO only instead of CO_2, will be proportional to the amount of carbon burned incompletely. This is represented by the ratio (CO/CO_2) as shown above, and for this reason the lines of A, along with this ratio is constant, will represent equal values of $L_{(co)}$. The total amount of losses in this case will therefore be

Per cent of loss $= (A + PB)\ (T - t) + C + L_{(co)}$

B and C depend only on the value of $CO_{2\ (max.)}$ and are for this reason constants for all cases covered by Fig. 2. Example. In the case marked on Fig. 2, the per cent loss $= (0.01784 + 0.2 \times 0.01715)\ (T - t) + 5.4 + 5.0$.

Routine Care and Operation of Air Compressors

AIR COMPRESSORS NEED CLEAN AIR, PROPER COOLING AND HIGH GRADE MINERAL OIL IN THE CYLINDERS. PROPER LUBRICATION OF ALL BEARINGS ALSO IS IMPORTANT

IN THE ROUTINE operation of air compressors many operators are prone to neglect some of the most important considerations of efficient and economical operation.

If an air compressor has been erected by the manufacturer, generally the job has been properly done, but sometimes, building changes necessitate removal of the compressor to another site. If, as is often the case, operators themselves take charge of the moving and re-erection, they should be as careful of all details as an erector sent by the company.

TABLE I. THIS TABLE SHOWS THE EFFECT OF INTAKE TEMPERATURE ON THE EFFICIENCY AND CAPACITY OF AIR COMPRESSORS. 60 DEG. F. IS TAKEN AS THE BASIS OF COMPARISON

Initial Temperature		Relative Capacities and Efficiencies	Initial Temperature		Relative Capacities and Efficiencies
Degrees Fahr.	Degrees Absolute		Degrees Fahr.	Degrees Absolute	
-20	441	1.18	70	531	.980
-10	451	1.155	80	541	.961
0	461	1.13	90	551	.944
10	471	1.104	100	561	.928
20	481	1.083	110	571	.912
30	491	1.061	120	581	.896
32	493	1.058	130	591	.880
40	501	1.040	140	601	.866
50	511	1.020	150	611	.852
60	521	1.000	160	621	.838

An item which often is not given much consideration is the location of the air intake. This should be on the north side of the compressor house, if possible, so as to obtain air from the coolest place. Carry it up 6 or 8 ft. from the ground and, if no patented air filtering device is available, cover the opening with a hood so that water will not drip into it and put a fine wire screen over the opening. The air intake should have an area at least 50 per cent of the area of the air piston. The longer the conduit the greater should be its diameter. A good rule is to increase it 1 in. in diameter over the size at the compressor for every 10 ft. in length.

AIR FILTERS MUST BE CAREFULLY DESIGNED

Air intakes should be made of wood (tin lined), brick, tile pipe or other nonconductors of heat. Tile pipe often is used because of its low conductivity and low cost. The design of the air filter at the outer end of the intake pipe is important for a small amount of dust constantly passing into the cylinder will cause rapid wearing of the valves and piston.

There are a number of different forms of filters which can be purchased ready to attach to the intake pipe. One which is in wide use consists of a box with a filter shell containing short brass tubes covered with viscosine. This filter gives good results with a negligible pressure drop and requires cleaning only once every six to ten weeks, depending on usage. Other forms of filters on the market are those which consist of a large surface of special felt through which the air must pass, and others which have a fan operated by the rush of air through the intake pipe. This, in turn, operates a centrifugal device and is supposed to whirl the dirt out of the air. Any filter which will clean the air may be used.

If the user prefers to construct his own filter a good method is shown in Fig. 1. This consists of a wooden frame covered with heavy ½-in. mesh wire, fastened on the inside of the frame, with removable frames covered with cheese cloth or loosely-woven cotton flannel placed against the wire which can be taken out and cleaned whenever necessary. A shed roof should be placed on top of the intake frame, with the roof projecting far enough to protect the screens from the weather.

When taking charge of an air compressor plant, the operator should inspect the piping carefully and if the

installation has been faulty make the necessary changes. An approved method of piping is shown in Fig. 2. The air discharge pipe from the compressor should be run to the top of the receiver and the main air line from the receiver connected near the bottom. If two or more compressors discharge into a common receiver or pipe line, it usually is necessary to place a gate valve on the pipe leading from each machine, so that it will be relieved of air pressure when not running. In such a case it is absolutely essential that a good-sized pop safety valve should be placed on the pipe between the valve and compressor, so that, should the latter be started with the gate valve shut, no damage will result. This safety valve may be arranged to be opened before starting the compressor in order to relieve the motor of excessive current load in starting.

Compressors Need Cooling Water

To obtain the most efficient results from the compressor, a proper supply of cooling water must be furnished

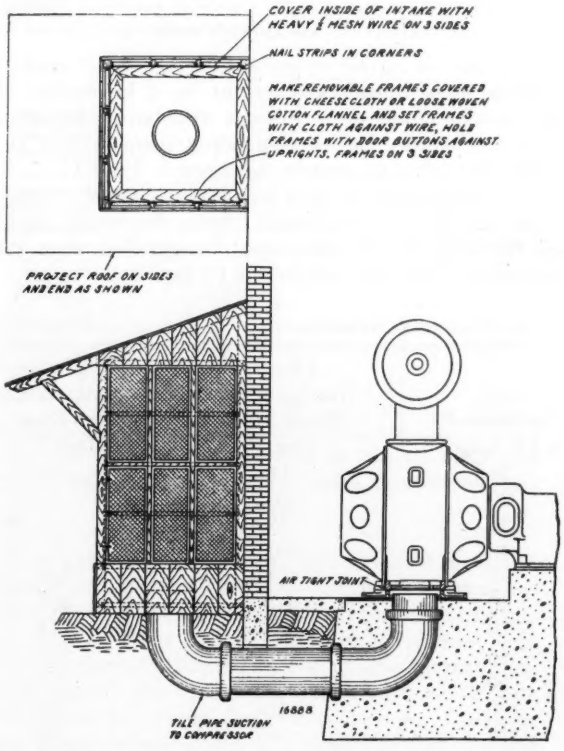

COVER INSIDE OF INTAKE WITH HEAVY ¼ MESH WIRE ON 3 SIDES
NAIL STRIPS IN CORNERS
MAKE REMOVABLE FRAMES COVERED WITH CHEESECLOTH OR LOOSE WOVEN COTTON FLANNEL AND SET FRAMES WITH CLOTH AGAINST WIRE, HOLD FRAMES WITH DOOR BUTTONS AGAINST UPRIGHTS. FRAMES ON 3 SIDES
PROJECT ROOF ON SIDES AND END AS SHOWN
AIR TIGHT JOINT
16888
TILE PIPE SUCTION TO COMPRESSOR

FIG. 1. THIS IS A HOME-MADE CONSTRUCTION OF AN AIR FILTER FOR AN AIR COMPRESSOR

to the jackets and intercooler. The amount of water required is from 1 to 1½ gal. for each 100 cu. ft. of free air, depending upon the initial temperature of the water. It is advisable not to put any valve on the discharge pipe, particularly when the water supply is under considerable pressure, as injurious strains may be placed upon the cylinders and intercooler. The end of this pipe should be located at an accessible point so that it may easily be seen and any stoppage of the flow of water through the jackets quickly noticed. A good arrangement is to have the jacket outlet pipe discharge into a small funnel in the pipe for carrying off the water, leaving sufficient space between the two for observing the flow.

In no case should the outlet pipe be connected direct to the shop piping system. If a closed pipe is used, it must be of abundant size to prevent back pressure on the intercooler.

All water spaces and air passages in which water is likely to accumulate are provided with outlets and drain cocks. It is hardly necessary to call attention to the great importance of opening all such drains whenever the compressor is shut down for any considerable time in freezing weather. Neglect of this precaution is sure to result in burst cylinders and piping.

If compressed air is used to blow out water remaining in the jackets, it should not be turned on until abundant time has been given for drainage. If the air is turned on while a considerable amount of water is still in the machine, the resultant pressure is quite likely to cause damage to heads and jackets, to say nothing of leakage.

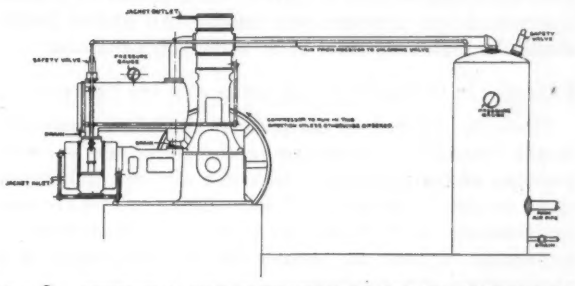


FIG. 2. HERE IS A SIDE ELEVATION OF AN AIR COMPRESSOR SHOWING AN APPROVED METHOD OF PIPING

Starting the Compressor

Turn the compressor over a couple of times by hand to be sure everything is free when ready to start. The proper direction of rotation is so that the top of the flywheel travels towards the cylinder, or as it is commonly called, "the engine runs under."

See that the compressor is "unloaded" by opening a valve in the air line so that the compressor can run without building up air pressure in the receiver, or open the two indicator cocks in the side of the air cylinder.

Turn on the circulating water in the air cylinder jacket. On steam driven compressors open the drain cocks on the steam cylinder and drain the steam pipe above the throttle valve until it is warmed up, then open the throttle a little and let the steam blow through the steam cylinder until it is thoroughly heated up, turning the engine over so that the steam blows first through one end, and then through the other. When well warmed up, give it a little more steam and let it run slowly a while, gradually bringing it up to speed. Watch the governing devices and satisfy yourself that they are operating properly and will control the engine. Examine oiling devices and see that bearings are cool.

Most high grade fibrous packings are composed largely of asbestos with a lubricant and graphite freely mixed in. In applying the packing in the stuffing box of a compressor, insert the rings so that the joints come at different points around the rod. Fill the box with packing and force it in slightly with the gland. Do not use a wrench on the gland stud nuts. The packing must

not be crowded too tightly at first as this will only squeeze out the lubricant and cause the packing to become hard and unyielding. Draw the gland up slightly and after the compressor has warmed up, follow it up just enough to prevent blowing.

If packing becomes hard it sometimes may be removed and loosened up and a mixture of graphite and grease worked into it. The use of packing often is misunderstood and, by being tightened up too much, causes heating, scoring and cutting of the rod.

Any asbestos body sheet packing can be used for gaskets between air cylinders and heads. Rubber packing is not satisfactory as the heat and oil in time often soften it. Material for air head gaskets should be of the same thickness as that originally used to insure proper clearance between piston and heads. All gasket joints should be pulled up tight after a few days running.

Freezing in Compressed Air Lines and Its Prevention

Moisture carried in compressed air, when deposited in the transmission pipes or in the ports and exhaust passages of the machinery using the air, will sometimes cause trouble by freezing. This condition can be avoided by installing an aftercooler or suitable moisture removal apparatus as near as possible to the compressor and ahead of the air received.

Lubrication Pointers

Lubrication of air compressors has been given considerable study by the Compressed Air Society and the following recommendations given:

Satisfactory lubrication of air compressor cylinders is attained by securing, (1) the reduction of friction to a minimum and, (2) elimination of carbonization of the oil as far as possible.

For the proper reduction of friction, the oil chosen should have sufficient body to sustain the weight of the moving parts and to form a seal between the piston rings and the cylinder walls, and still not absorb excessive power in overcoming the viscosity of the oil itself.

Objections to air cylinder oils which allow more than the slight amount of carbonization which appears unavoidable, are, of course, well known but may be briefly stated for the purpose of clarifying what follows:

Carbonization of the oil allows the accumulation of deposits of carbon which are sticky in the early stages of their formation but hard and flinty later. Such deposits accumulate on the cylinder valves, in the cylinder passages, in the pipes and eventually in the air receiver.

Sticking or partial closing of the valves and their consequent failure to act properly is probably the chief objection to the action from the standpoint of the efficient operation of the compressor.

Formation of excessive carbon deposits is apt to be due to any one or more of the following causes:

1. Ill-advised use of some oil, such as a steam cylinder oil, which easily decomposes in the heat of the air cylinder.

2. Use of oils of too great a viscosity—commonly referred to as "too heavy oils." These do not atomize readily and, therefore, remain too long upon the hot cylinder walls, thus baking down to sticky carbon deposits.

3. Use of too great quantities of oil, which has the same effect as the use of too heavy an oil as far as the carbonization is concerned.

4. Failure to provide a proper screen over the air intake of the compressor, thus allowing free entrance of dangerous dust (especially coal dust).

Objection to this carbonization aside from the sticking of air valves and choking of the air passages is the menace of fire entailed by carbon deposits. Carbon particles torn loose from them may become incandescent from causes which could not be anticipated by the compressor manufacturer. If such incandescent carbon particles should happen to come in contact with "oil vapor" given off by the lubricating oil, a fire possibly might be started whose menace would be small or large depending upon how much carbon had been allowed to accumulate in the compressor and piping to the receiver. If these are kept properly cleansed at all times, there should never be a time of any danger.

This oil vapor is given off from a lubricating oil at a certain temperature called its "flash point" just as steam arises from water at a certain point.

Heat of Air Compression

Selection of an air cylinder lubricant is, of course, governed to a considerable extent by a knowledge of the cylinder temperature it must withstand. Knowing the air pressures, the corresponding temperatures are ascertained fairly accurately, as shown in Table II.

This table gives the final temperature in the cylinder at the end of the compression stroke, for single stage, also for two stage (or compound) compression, when the free air entering the cylinder is 60 deg. F.

TABLE II. CYLINDER TEMPERATURES AT END OF COMPRESSION

Air Compressed to Lb. Gage	Final Temperature Single Stage Deg. F.	Final Temperature Two Stage Deg. F.
10	145	...
20	207	...
30	255	...
40	302	...
50	339	188
60	375	203
70	405	214
80	432	224
90	459	234
100	485	243
110	507	250
120	529	257
130	550	265
140	570	272
150	589	279
200	672	309
250	749	331

Variations from these temperatures will occur in actual practice due to water jacketed air cylinders and radiation tending to lower the temperature at the higher pressures. But at, say, 50 lb. pressure and lower, the heat is likely to be somewhat greater than given by the table, particularly if the compressor is run at high speed and also if it is not water jacketed.

The natural inference of the reader, after noting the

temperatures in Table II, is that he must select an air cylinder oil whose flash point is higher than the maximum temperature which may be encountered within the air cylinder. As a matter of fact, this is not the case and it need only be carefully noted that: the study of the air cylinder temperatures is useful mainly in testing lubricating oils to determine their resistance against breaking down into carbon and volatile compounds. But such temperatures cannot be taken as limits establishing the lowest allowable flash point for a lubricant safe to use in the air cylinders.

Qualities of Cylinder Lubricating Oils

For average normal conditions, the oil should be a medium bodied pure mineral oil of the highest quality, not compounded with fixed oils such as animal or vegetable, and should be carefully filtered in the final process of manufacture.

Quite a range of oil composition is permissible for lubricants approved for this work, which are manufactured under the above conditions. Primarily, a distinction must be made between those oils having a paraffin base as distinguished from those having an asphaltic base.

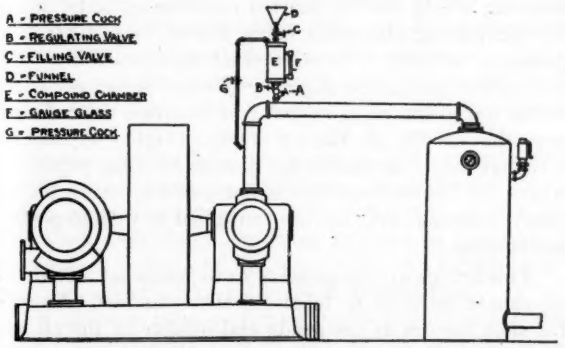


FIG. 3. FOR CLEANING OUT CARBON IN THE AIR DISCHARGE LINE AND RECEIVER OF AIR COMPRESSORS THIS DEVICE MAY BE USED

From a strictly operating standpoint—so it is claimed by some lubricant manufacturers—there is no distinction between these two classes of lubricants as to their desirability as compressor cylinder oils, provided that both have been properly filtered in the process of manufacture to remove the carbon forming elements. If any carbon should be formed, however, such carbon deposited by the asphaltic base oils is of a light fluffy nature and easily cleaned out, whereas, that deposited by the paraffin base oil is very adhesive, and characterized by a hard, flinty nature.

Discharge Line and Receiver Should Have Periodic Cleaning

Even the best of lubricating oils will cause the deposit of enough carbon in the compressor system to necessitate periodic cleaning.

For the removal of carbon, the machine operator should confine his efforts to the use of soap suds. A good cleansing solution is made of one part soft soap to fifteen parts water. These suds should take the place of oil for a few hours, and be fed into the air cylinders about once a week, either by means of a hand pump or through the regular lubricator at a rate about ten times as rapidly as that of the oil. The cleanliness of the air valves when inspected periodically, as they should be, will indicate whether more or less soap suds should be made. After using soap suds, open the drain cock of the air receiver and of the intercooler, in the case of compound machines, to draw off any accumulated liquid. Oil should be used again for a half hour before shutting down the machine, in order to prevent rusting the cylinder and its fittings. Never use kerosene, gasoline or lighter oils in an air cylinder for any purpose whatever, because of their volatile nature under heated conditions.

It often happens that oil, carbon and other foreign matters are deposited in the air discharge lines and air receiver. A practical method of cleaning these is shown in Fig. 3, where a receptacle made of 6-in. pipe is shown set on top of the discharge pipe. This shows plainly the construction and what the different parts represent. If a mixture of 1 lb. of Red Seal lye and 18 lb. of water is passed into the discharge line at the rate of 60 or 70 drops per minute while the compressor is running, this will eat out all the accumulation on the surface of the pipe and in the receiver, and if the blowoff valve on the receiver is open, all of this foreign matter will be discharged therefrom. This cleaning solution can be used every month or two depending on how much accumulation there may be in the receiver.

To use compound: Close Cock "A" and "G", open Valve "C" and fill compound through funnel "D". When Chamber "E" is filled, close valve "C", open cocks "G" and "A", and regulate feed by valve "B"; use about 70 drops per minute.

Observations on Changing Tested Oils

When the operator of an air compressor succeeds in obtaining lubricating oils that are giving satisfactory results, he should be cautious about making a change to other grades, particularly if cheapening the cost is advocated by purchasing and sales agents. But if a change is decided on, the performance of the new lubricants should be most carefully checked up before damage can occur to the rubbing surfaces of the compressor, and to see that no increased amount of deposit collects on the inside walls of the air receiver.

The most satisfactory way to get lubrication results is to seek the advice of the local experts of any reputable lubricating companies, and to be governed by their recommendations, which, however, should be based on the foregoing statement.

Discussing the development of water powers in California before the Spring meeting of the A. S. M. E., H. A. Barre of the Southern California Edison Co. called attention to the increased economy of Long Beach and Seal Beach steam plants, which are delivering 425 to 450 kw-hr. per bbl. of oil, or at a cost of 2¼ mills per kw-hr. with oil at $1 a barrel. With these figures, he stated that additional plants to use unregulated stream flow are practically out of the question and even plants with water storage in reservoirs for the dry season must be scrutinized carefully as to the economies of making the development.

The most satisfactory expansion joint for use in pipe lines is the double offset expansion U bend.

Lubrication Needs of Oil Engines*

FACTORS AFFECTING TWO CYCLE ENGINE OPERATION DEPEND UPON EXTERNAL AS WELL AS INTERNAL CONDITIONS

IN THE DEVELOPMENT of power generation equipment, especially adapted to the operation of such machinery as electrical generators, compressors, and ice machines in stationary practice, and for the propulsion of ships and driving marine auxiliaries, the oil engine has been especially prominent. In fact, in the marine field, according to a current survey, constructional work on motorships recently commenced exceeded that on steamships by a slight margin.

While the fuel is essentially the factor which makes the oil engine run, the lubricants, in turn, are the necessary means which must be used to keep it running to develop maximum power with a minimum fuel consumption.

Regardless of whether a lubricant is to serve the engine cylinders or is to be used on bearings, it must possess a number of basic characteristics, viz:

1. It must be carefully refined to withstand the usual stresses and strain of intensive service.
2. It must be suited to the engine and to the lubricating system installed.
3. It must be of such a viscosity, or body, as to maintain a lubricating film of suitable thickness between the wearing surfaces without undue friction.
4. It should be sufficiently adhesive to resist being squeezed out from between the wearing surfaces when subjected to the normal pressures of operation.
5. It should not congeal at any of the lower temperatures to which it might be subjected during storage or operation.
6. It should be capable of spreading readily over the wearing surfaces.
7. It should have a low emulsification tendency.
8. It must have a low carbon residue or tar-forming tendency.

CARE SHOULD BE EXERCISED AFTER OIL LEAVES REFINERY

It is fully appreciated that for an oil to meet all the above requirements the most careful attention is necessary not only in refining, but also in transportation, storage and handling in the plant. Yet if carefully designed the two-cycle engine is not difficult to lubricate properly. In fact, the cylinders are the only parts requiring more than usual attention from a lubricating point of view, due to the fact that the oil is subjected to high temperatures at more frequent intervals over each cycle, while the high velocity of the gases of combustion at the exhaust ports increases the vaporization of the lubricant in this region of the cylinder.

Quite as important as the grade of oil used for cylinder lubrication is the method and rate of application. The oil should be so fed as to impinge directly onto the pistons, the time and point of application being so planned that the charge will strike between the first and second rings when the piston is at the lowermost point of its stroke.

The number of points at which the lubricant should be applied to the piston of an oil engine will depend naturally upon the type and size of the engine. Care should be taken that none of these oil holes are located in line vertically with the exhaust ports, otherwise the exhaust gases will tend to carry off a certain amount of lubricant.

PISTON RINGS CONTROL CYLINDER LUBRICATION TO A GREAT EXTENT

The effectiveness with which the lubricant will be distributed will also depend to a certain extent upon the fit of the piston rings. Loose rings will not only decrease this but also will allow blow-by to occur. The loss of compression and passage of hot gases which will result will naturally tend to cause overheating of the lower parts of the cylinder and piston, the oil film being either burned or dried up prematurely.

On the other hand, where the rings are too tight a scraping action will be exerted over the cylinder walls, the lubricating film often being broken or at least dangerously reduced. To counteract this possibility certain authorities advise slight beveling of the upper edges of the top piston rings in order to facilitate their sliding over the oil film on the up stroke. Tight, improperly set rings may also lead to the pistons sticking, especially where the lubricating film is not perfect, where an excessive amount of oil has been supplied or with imperfect combustion.

This brings up the question as to just what amount of oil should be used to lubricate the cylinders. Usually for such factors as the grade and quality of the oil, the method of application, the number of oil feeds and the type and construction of the engine must be considered. In general, while certain figures (such as, say, 10 to 20 drops per minute) could be quoted, based on ideal operating conditions, it is safe to state that a certain amount of experimentation should always be carried out, for practically every oil will vary in its lubricating ability dependent upon its viscosity and manner of refinement. Where a mechanical force feed lubricator is used, capable of feeding oil in synchronism with the strokes of the pistons, frequently it is possible to control the oil feed so accurately as to approximate the theoretical requirements of the engine for the particular oil in service.

ALL ENGINE PARTS MUST BE CAREFULLY CONSIDERED

Other pertinent bearing parts of the two-stroke cycle oil engine which require careful lubrication are the wristpins, the crankpins, main bearings and crosshead guides. Pressures are usually high, clearances low and operating speeds above the average in steam practice, yet the circulating force feed oiling system, the mechanical lubricator, or the principles of splash lubrication (in the enclosed crankcase engine) are all readily adaptable.

On large engines the first is preferred by many authorities. In effect it is probably the most dependable system in that it furnishes a continuous stream of oil

*Abstracted from Lubrication and reprinted with permission of the Texas Co.

to all the bearing parts in question and is capable of being put in series with a filtration or purification system which will insure the delivery of practically pure oil.

Abnormally high cylinder temperatures are a detriment to efficient operation in that they are a hindrance to effective combustion and lubrication with the resultant necessity for increased oil supply. Therefore temperatures in excess of those required for efficient combustion must be avoided. In general they will be caused by overloading the engine, improperly designed cooling systems, the use of too little cooling water, obstructions in the water pipes, jackets and waterways of the engine.

In order to maintain a flow of cooling water through an oil engine such that the discharge temperature will be in the neighborhood of 140 to 150 deg. F. a certain amount, depending upon the inlet and outlet temperatures, will have to be circulated, the extent to which heat transfer takes place and the amount of heat given up by the fuel to the engine. Normally from 8 to 10 gal. of water per brake hp-hr. is required for suitable engine cooling under average operating conditions.

Purification Systems as Important as Oil Supply

Quite as important as the proper selection of lubricants for the two-cycle oil engine is the matter of their purification during operation. Sediment will accumulate and water of condensation is always a possibility. Emulsification and sludging will be the natural sequences if oils so contaminated are continued in service, clogged oil ways and bearing troubles being the culmination.

Carbon, which is a prevalent contaminating agent, is also a sludge creator, tending to impair proper lubrication even when held in free suspension in the oil. Filtration, centrifugal action, or agitation in presence of a coagulent capable of throwing down the carbon, however, are all effective methods of purification.

In addition these systems serve to remove water and other contaminating foreign matter. It must be borne in mind, that a certain amount of loss will accrue which must be taken care of by the periodic addition of a suitable amount of new or purified make-up oil.

Impure air in plants where dusty materials or products are being handled is also the frequent source of foreign matter, which as it usually consists of siliceous particles, has a decided scoring or abrasive ability. Of course, the oil purifier will remove such matter, but it is better to remove it at the source by using some filtering medium at the intake.

Diesel Engines Help the Southwest

Development of Certain Districts Accelerated by Small Engine. By E. Nevins*

TWENTY YEARS AGO there were in Texas two Diesel engine plants, one, the Sherman Electric Co., with two 225-hp. engines and another at Dallas, a 50-hp. engine driving part of a brewery. Today there is hardly a town in the state that does not have one or more engines ranging from 10 to 1000 hp. They are used in tractors, ice factories, locomotives, dredges, rock crushers, hoists, ditch machines, cotton gins, pumping plants, farms, oil wells and brick plants. Running under all conditions of weather, care and supervision, some of them are outdoors, some are in concrete buildings with oil filters and attention, and some just run as the Mexican help starts them.

Recently in a plant that had been in operation about 10 yr., the engineer could not take up on the bearings because, if he lifted the caps to take out liners, the broken babbit would fall out. There was a slight knock due to about a quarter inch play but the exhaust was nearly smokeless with the kw.'s rattling out at the rate of 10 per gallon of fuel oil. A nice thing about an old Diesel is, if it can be coaxed to run with a clear exhaust and all parts stay together the efficiency is as good as ever.

Without the oil engine of the simple solid injecting type there are a great many parts of the southwest that would not be developed as they are now. Can you imagine a farmer using a steam plant to pump water for irrigating 10 to 100 acres and hauling his fuel 25 or more miles? One barrel of fuel oil will run his oil engine for several days.

As a standby plant the larger sizes are being used at the end of transmission lines. They can be started and carrying full load in less than 5 min. The standby cost is for labor and capital charges only as the fuel cost is in proportion to the load on the plant. One large power company uses Diesels to carry the load of smaller plants till they can be connected to transmission systems after which they are either moved to new location or left to serve as standby units with small operating force.

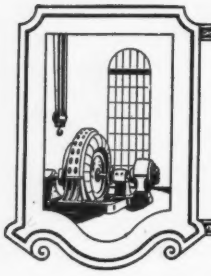
Reliability of Oil Engine No Longer Doubtful

Regarding the matter of reliability, a published tabulation of 57 engines (and possibly 57 varieties), 300 hp. or under, gives the longest shut-down as 3 hr. and, with the exception of one 50-hp. machine that was off 321 hr. due to broken shaft, the total yearly lost time due to engine failure was 8 hr. for the 56 engines. The longest continuous run was 3360 hr. and the shortest 16 hr. while years in service varied from one to ten, the engine with the broken shaft being 10 yr. old.

From 1905 to 1910 the plant of the Sherman Texas Electric Co. was operated with two engines and from 1910 to 1914 with three 225-hp. engines, at least two of which were always necessary to carry the load. After 1912 three were necessary several days each week but the total plant shut-down, due to engine failure, was not over 1 hr. for these 9 yr. The lighting system of Alamogordo, New Mexico, depended on one Diesel engine for 9 yr.; the makers of the engine claim that the city paid $60 for new parts during this time. El Paso depends on Diesels for part of its water supply, while many towns in the southwest with only one engine and no standby power depend upon it for their lights and water.

Maintenance costs covering a long period of time and a large number of engines will average about one dollar per 2000 hp-hr. for the smaller sizes or 5000 hp-hr. for the larger sizes around 1000 hp. This is an uncertain item of considerable importance in the matter of operating costs and depends to a large extent upon the class of labor available and the ability of the engineer.

*Chief Mech. Eng., City of El Paso, Tex. From a paper presented during Oil and Gas Power Week.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Underground Electric Transmission

INTERNAL IONIZATION THEORY POINTS WAY TO THE DESIGN OF HIGH VOLTAGE UNDERGROUND CABLE

DURING THE past decade we have witnessed enormous progress in the overhead transmission of electric power, and, no matter which part of this country we visit, we see tangible evidence of this progress in the long lines of transmission towers everywhere. Economic considerations demand that power be transmitted in volts rather than in amperes and so, our transmission voltages have increased steadily until today lines of 220,000 v. are a reality.

In large cities or in other congested districts, however, it is impractical to employ high potentials on overhead lines and the problem of constructing suitable high voltage underground transmission lines has made its appearance. To the person not following developments in this field, there are no visible signs, such as tower lines, to remind him of progress in underground transmission, nevertheless great progress has been made. While the overhead construction department has been erecting tower lines the underground distribution engineers have not been idle.

It is only within recent years that cables operating at voltages above 20,000 v. have come into use. Not long ago 33,000 v. was believed to be close to the limit of safe operating pressures for paper insulated cable. When the Calumet Station of the Commonwealth Edison Co. of Chicago was placed in operation early in 1922, a 33,000-v. underground tie line, installed between that station and Fisk Street Station was considered, to be the highest voltage cable in America. By way of contrast, just recently it is reported that a 132-kv. cable is being installed by the same company between Evanston, Ill., and Northwest station in Chicago. In Philadelphia, the Philadelphia Electric Co. has installed two underground lines, each about 20,000 ft. long rated at 75 kv. and in Cleveland there is in operation a cable at 66 kv.

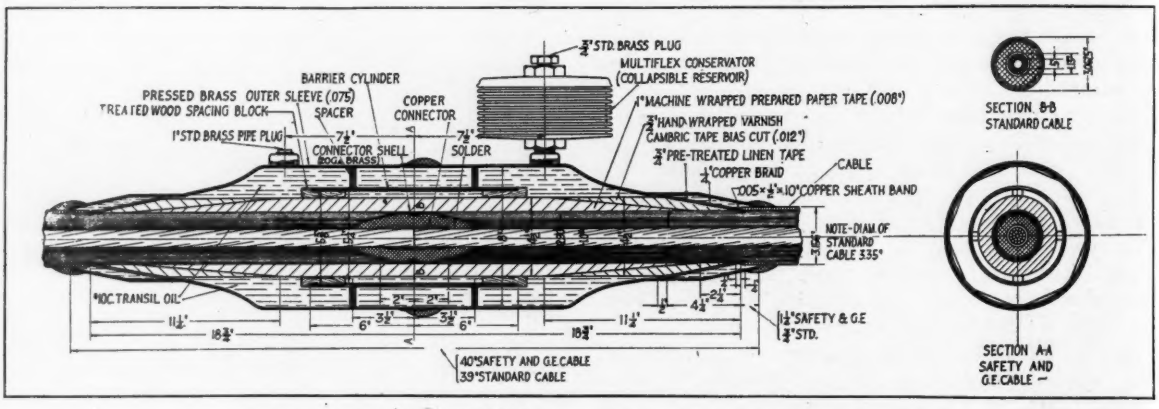


FIG. 1. JOINT FOR 750,000-C.M. SINGLE CONDUCTOR 75-KV. CABLE

These few installations reflect the progress that has been made in underground transmission and show that the possibilities of high potential transmission is not limited to overhead lines.

This development in underground transmission has been brought about mainly by a better understanding of certain principles, involved in cable construction. The principles referred to are based upon the internal ionization theory. It has been proved that insulation breakdown in cables is caused largely by ionization of voids or gas spaces in the insulating material of the cable. Regardless of how excellent the quality of the insulating material or the impregnating compound, if spaces or voids are present, the breakdown voltage will be reduced materially. The existence of such voids in cables, therefore, is a limiting factor in the production of a cable capable of withstanding the voltages which modern economic considerations demand. The construction of a cable might be so poor that it could not safely be operated at a maximum stress of more than 12 kv. per cm. thickness of the insulation, simply because of the existence of voids.

For our ability to overcome the limitations imposed

by internal ionization in cables, we are indebted to Europe. It was the development of the Pirelli cable in Italy, employing a hollow core filled with liquid or semi-liquid insulating compound that solved the problem. This type of cable is now being manufactured in America.

The Pirelli cable is made up of a number of copper wires stranded around an iron wire spiral which leaves a hollow core. The insulating paper (a tape 43/64 in. wide) is wrapped around the copper wires in the normal way and is covered with lead, after which a protecting layer of paper and tarred jute has been applied. An interesting feature of this cable is that the impregnating of the paper is done after the lead has been applied. The moisture is removed by a current of dry air sent through the hollow core; then a vacuum is applied, after which the fluid compound is allowed to flow in.

The new oil filled cables made in America are built on the same principle. Elaborate precautions are taken to eliminate voids initially and to prevent their formation during the life of the cable. Essentially, this is accomplished as follows:

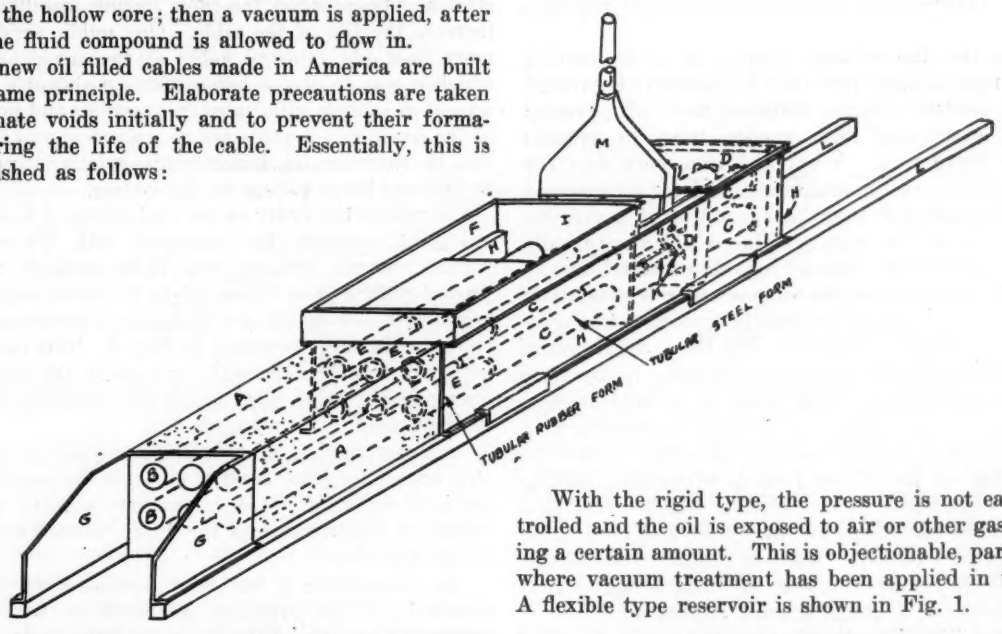


FIG. 2. DIAGRAM OF MONOLITHIC CONDUIT FORMING MACHINE

1. Using a relatively thin oil for impregnation and for filling the joints, terminals and reservoirs. Drying, impregnation, and filling with great care under heat and vacuum to remove all possible traces of moisture and gas.

2. A positive oil pressure is maintained throughout the entire cable volume at all times and under all conditions of operation. This is made possible by the free flow of oil along the cable length during heating and cooling.

The cable is sectionalized and expansion type closed reservoirs are inserted at the ends of these sections for maintaining a predetermined oil pressure at all points. With this cable, laboratory and field tests, indicate that a maximum working stress of 63 kv. per cm. selected for the present installations is within safe limits. When it is considered, that the working stress for the best grade of high tension cable made in the conventional way is about 30 kv. per cm., the superiority of the new oil filled cable will be apparent. Two, 132 kv. installations of the oil filled cable are being made in this country.

The use of reservoirs or conservators on cable joints is interesting. They not only maintain a constant oil pressure upon the cable but also guard against the danger of joint filling compound into cables which are not filled with oil. These reservoirs whether on the individual joints or at the end of line sections, can be of either the rigid or the expansible type. If of the rigid type, it is necessary to have them only partially filled with oil so as to leave a cushion of air or other gas to take care of expansion and contraction within the cable. The expansible or flexible reservoirs are completely filled with oil at all times, contraction and expansion being taken care of by movement of the walls. In both cases they are carefully sealed to avoid leakage and entrance of moisture and air.

With the rigid type, the pressure is not easily controlled and the oil is exposed to air or other gas, absorbing a certain amount. This is objectionable, particularly where vacuum treatment has been applied in the field. A flexible type reservoir is shown in Fig. 1.

Cable Joint Construction

Development in cable construction with the consequent increase in operating potentials have made it necessary to develop proper forms of joints. Ordinarily, a joint or splice in an electrical conductor is not thought of as anything complicated or on which a considerable amount of engineering ability could be bestowed. That this idea is incorrect, is shown by the section of a joint for a 75-kv. cable, shown in Fig. 1. It looks quite complicated, and it is. It is impossible in this general survey of the underground transmission situation, to describe the details of making a joint of this type, but a good general idea may be gathered from the illustration. It is an oil filled joint, the oil used, being No. 10 transil oil. The pressure on the oil is maintained constant by the collapsible reservoir shown at the top of the casing.

The technique of making joints in high voltage cables is an extremely important part of the work of the installation department, since improper care in the making of a joint may lead to the destruction of an expensive cable, and it deserves all the study that is being given it.

Parallel with the advances in cable design, there have been developed new methods in conduit construction. In order to provide for the safe distribution of electricity in large current capacities and at high voltages, it

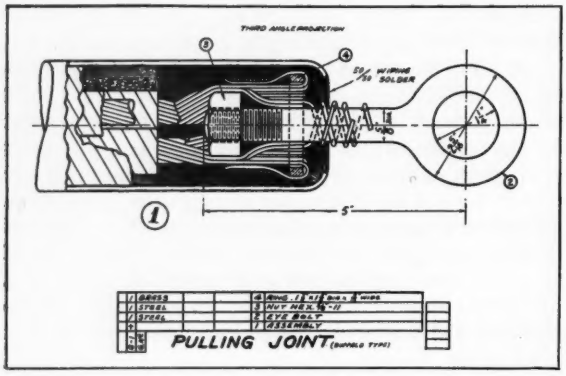


FIG. 3. PULLING EYE TO RELIEVE STRAIN ON CASING

is essential that the conduits housing the cables be of a fireproof material and that they be carefully separated.

Early conduit systems installed were of a varied character, everything from wooden tubes to wrought iron pipe being used. Wood and iron were soon followed by the use of tile and fibre, and later by concrete. During the past few years, a new form of monolithic duct construction has been introduced which apparently has many advantages both as regards construction and cost. With this method continuous concrete conduit of as many ducts as desired is actually constructed in place by means of special apparatus. The basis of the system is the employment of a heavy-walled tubular rubber form of special composition which serves as a mold or core. The tubular form is placed in position wherever a duct is desired and is then encased in concrete. When the concrete has set the rubber form is withdrawn, leaving a smooth round hole in the concrete which serves as a duct. The rubber forms are used over and over again for an indefinite period. In actual practice a monolithic conduit of the required number of ducts is built at one time by means of a special spacing apparatus.

Figure 2 illustrates the character of equipment used in this form of cable construction. The machine contains a series of tubular steel forms C uniformly spaced and rigidly clamped by the supporting frames D. Inserted within each of the steel tubes is a tubular rubber form E which protrudes a short distance beyond the end of the steel tubes into the concrete. The section marked I is a movable steel bulkhead which is actuated by the handle J through the toggle arrangement K and serves as a packing plate.

To explain the operation of this equipment we will consider the construction of this conduit bank from the point illustrated in the sketch. Concrete, mixed to a semi-dry consistency is shoveled into the receiving pan F of the apparatus and thence into the working chamber formed by the end of the previously constructed bank A and the side aprons H and the packing plate I of the apparatus. When the chamber has been completely filled with tamped concrete, the handle J is pushed forward to the end of its stroke. Throughout the first quarter of its stroke the function of the handle is to force the packing plate I back against the freshly placed and tamped concrete, thereby compressing it to the proper density. When the limit of compression has been attained, the friction between the apparatus and the track L on which it rides is overcome, with the result that through the balance of the stroke, the handle J, automatically propels the apparatus forward along the bottom of the trench for a distance of nine inches. The handle is then raised to the position shown in the sketch, pulling the packing plate away from the concrete and thereby providing a new working chamber. The operations are then repeated.

Cable Installation

In the actual installation of cables in conduit, more attention is being paid to the effects of pulling stresses. When a cable is pulled into or withdrawn from a duct through a manhole, it is subjected to strains which have a damaging effect upon its insulating qualities. Any method or equipment, therefore, which will reduce the strains imposed upon the cable during installation will increase the life of the cable. One public service company does not reinstall cable at the same voltage to which it was subjected before being withdrawn. When a piece of cable is withdrawn from service and pulled out of the conduit, it is subjected to a physical and electrical test, to determine its characteristics relative to operating at the next lower voltage on the system.

To reduce the strain on the lead casing of a cable, one operating company has arranged with the manufacturers, who will furnish their 75-kv. cable to have approved pulling eyes connected to the outer end of each reel length. A detail of a pulling eye recommended by one manufacturer is shown in Fig. 3. This eye, it will be noted, transfers the pulling stress to the copper conductor in the cable, eliminating the possibility of stripping the lead.

Another method of reducing the wear on cables as they are pulled into or out of ducts, is the use of various types of rollers of wood, aluminum, bakelite, lead and rubber at the entrance of the duct. These have proved highly effective.

In this article it has been possible only to direct attention to the principal advances in underground transmission work. No mention has been made of developments for testing cable both at the factory and when installed in the conduit, of methods developed for measuring the pulling stresses when cables are being drawn into the duct, of the developments in manhole construction and the many ingenious fittings developed for switching and isolating cable sections. Progress is being made in all of these branches of underground transmission but space does not permit a detailed discussion here.

The outstanding development, however, is the development of the oil insulated cable referred to at the beginning of this article. This has been the most notable step forward in cable design witnessed in recent years. It makes possible for the first time the continuation in cities, of incoming overhead high tension transmission lines without the necessity for stepdown transformer stations.

Electric service continues to expand. Daily output for stations was 199,700,000 kw-hr. in February this year as compared with 197,300,000 kw-hr. in February, 1925, and the first two months of 1926 showed 11,709,000,000 kw-hr. as compared with 10,554,000,000 kw-hr. for 1925. This is at an annual rate of 70,000,000,000 kw-hr. for 1926 as against an actual output of about 65,650,000,000 kw-hr. for 1925.

Air Circuit Breakers Handle Great Overloads

150-Amp. Air-Break Circuit Breakers Tested at St. Louis Successfully Handle Currents of Over 11,000 Amp.

EQUIPMENT was desired by the Union Gas & Electric Co. of Cincinnati, O., which would stand up to unusually severe conditions and, in considering the question of circuit breakers it was decided to run a series of tests which would prove, beyond doubt, that the apparatus would be able to handle currents and situations far more severe than would ever be encountered in station operation.

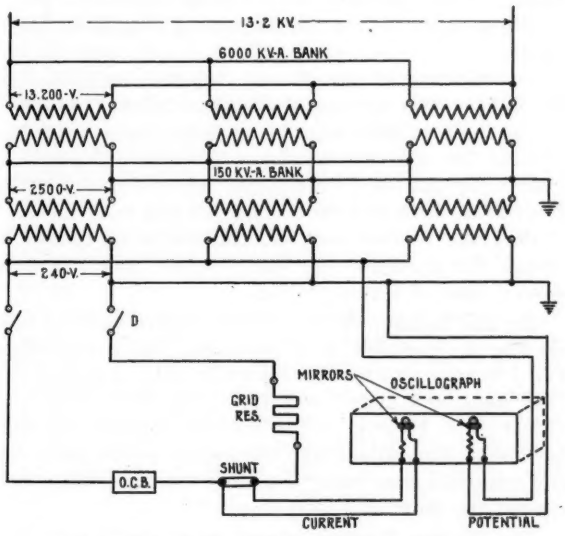


FIG. 1. CIRCUIT FOR 220-V. SHORT CIRCUIT TESTS

These tests were conducted and reported by J. P. McFarlan, Test Engineer of the company, and resulted in remarkable performance in handling currents greatly in excess of the rated capacity of the breakers. The breakers tested, of air-break type, varied from 15 to 150 amp. rating and for 220 to 440 v. but the currents handled ran from 680 up to 7300 amp. for the 15-amp. breaker, from 729 to 17,500 amp. for the 30-amp. breaker and from 200 to 8500 amp. on the 60-amp. breaker at 200 v. At 440 v., the 15-amp. breaker handled 889 up to 7490 amp. and the 150-amp. breaker, 3575 amp. to 22,950 amp. A 150-amp. instrument for 220 v. handled 1267 up to 11,600 amp., but found a limit at 13,200 amp., which is certainly not to be wondered at.

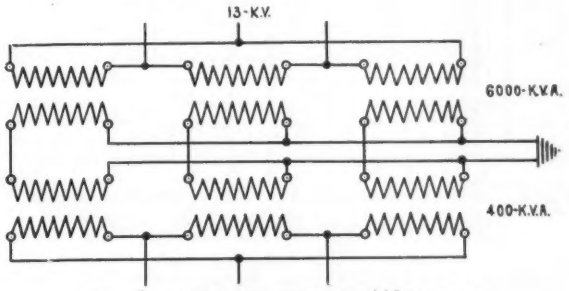


FIG. 2. ARRANGEMENT FOR 440-V. TEST

Curves herewith show the series of tests made and the action of the Urelite breakers made by the Cutter Co. Philadelphia, Pa. For loading them, the equipment for the tests was three single-phase, 2000-kv.a. transformers with ratio of 13 kv. to 2.5 kv., connected to a 13.2-kv. line. In the first series, these were connected in parallel on high and low sides and three single-phase transformers with total capacity of 150 kv.a. were connected to the 2.5-kv. side of the 6000-kv.a. bank, delivering 240 v. for the circuit breaker, Fig. 1. Later the capacity of the low-voltage bank was increased to 250 kv.a. For the 3-phase test, the high-voltage bank was connected in

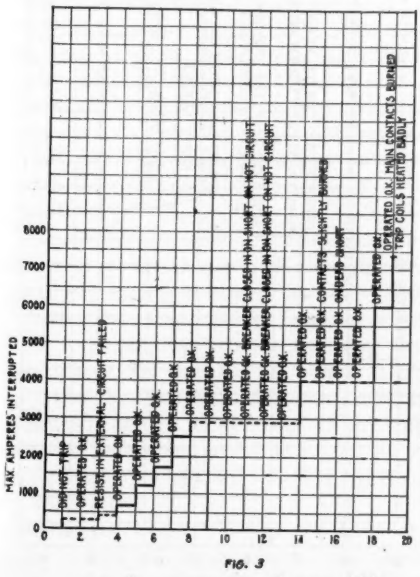


FIG. 3. TESTS ON 15-AMP.-220-V. BREAKER

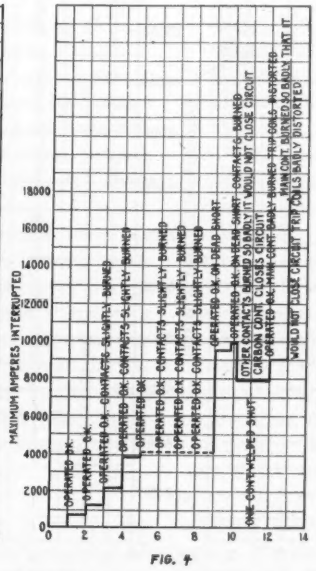


FIG. 4. RESULTS WITH 30-AMP.-220-V. BREAKER

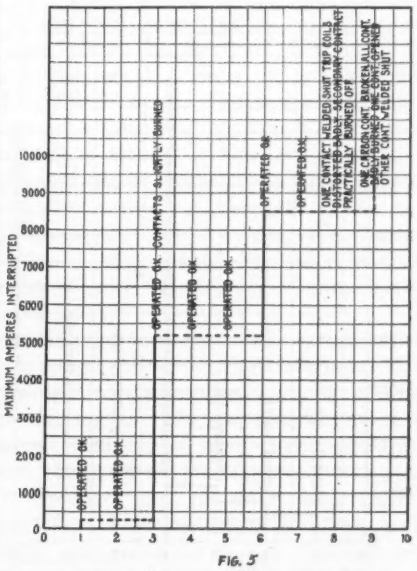


FIG. 5. 60-AMP.-220-V. BREAKER TESTS

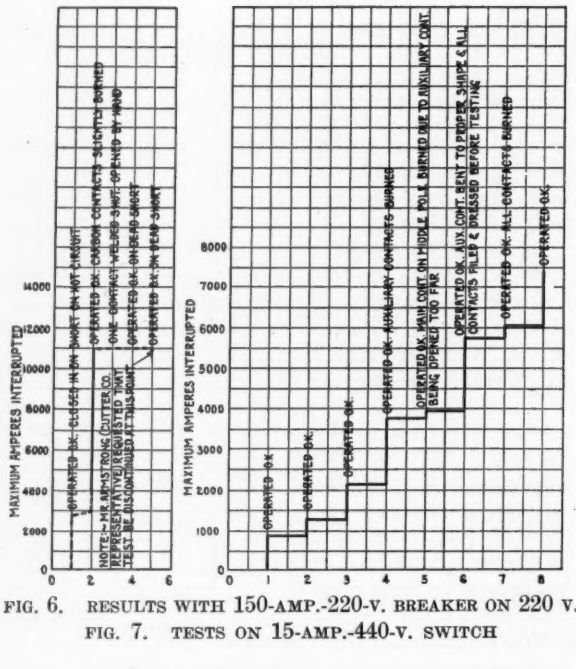

MAXIMUM AMPERES INTERRUPTED
OPERATED O.K. CLOSED IN ON SHORT ON HOT CIRCUIT
OPERATED O.K. CARBON CONTACTS SLIGHTLY BURNED
ONE CONTACT WELDED SHUT, OPENED BY HAND
OPERATED O.K. ON DEAD SHORT
OPERATED O.K. ON DEAD SHORT
NOTE:- MR. ARMSTRONG (CUTLER CO. REPRESENTATIVE) REQUESTED THAT TEST BE DISCONTINUED AT THIS POINT
OPERATED O.K.
OPERATED O.K.
OPERATED O.K.
OPERATED O.K. AUXILIARY CONTACTS BURNED
OPERATED O.K. MAIN COIL ON MIDDLE POLE BURNED DUE TO AUXILIARY CONT. BEING OPENED TOO FAR
OPERATED O.K. AUX. CONT. BENT TO PROPER SHAPE & ALL CONTACTS FILED & DRESSED BEFORE TESTING
OPERATED O.K. ALL CONTACTS BURNED
OPERATED O.K.

FIG. 6. RESULTS WITH 150-AMP.-220-V. BREAKER ON 220 V.
FIG. 7. TESTS ON 15-AMP.-440-V. SWITCH

Y and fed into two 200-kv.a., 3-phase banks which were connected in parallel and supplied 440 v., 3-phase currents, Fig. 2. The same arrangement was used for the 440-v., single-phase tests.

Short-circuit tests were made at 220-v. single-phase, and 440-v., 3-phase.

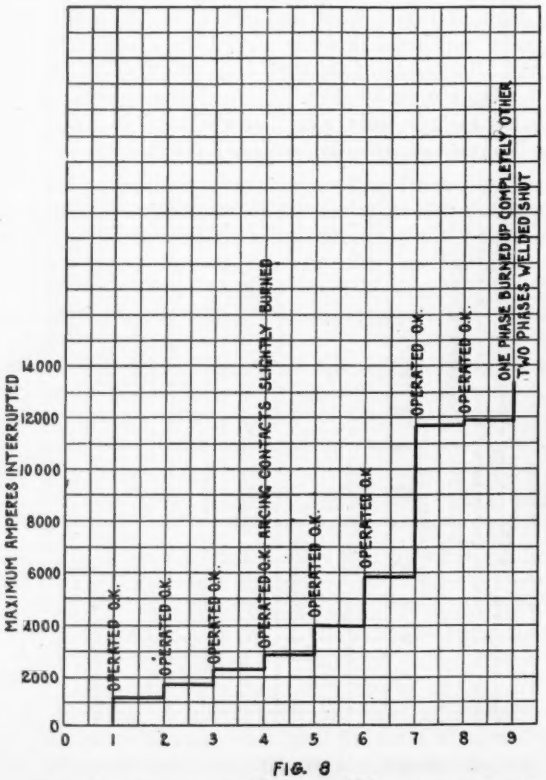
For these tests, four Urelite breakers were used. One was a three-pole, rated 15 amp. at 220 v.; the second a two-pole, rated 30 amp. at 250 v.; the third a two-pole, rated 60 amp. at 250 v.; and the fourth a two-pole, rated 150 amp. at 220 v.

In making the tests, a short was placed across two of the terminals and leads supplying current connected to the corresponding terminals. The breaker switch was then closed and the transformer bank energized by means of a remote control switch, which also started the oscillograph. The breaker then operated to clear the short circuit, after which the 13-kv. oil switch was opened. This gave twice the air break length of a phase to ground fault but the same length as a phase to phase short.

On the test of the 15-amp. breaker, as shown in Fig. 3, it opened eighteen shorts from 250 to 7300 amp., two of these at 2900 amp. being from closure on a hot circuit. The times in opening were: For 680 amp., 20 cycles; for 1230 and 7300 amp., 1.5 cycles; for 1726, 2500, 2930, 4045 and 6010 amp., 1 cycle. At the conclusion, the breaker was still in operating condition, though the contacts were badly burned and trip coils showed signs of severe heating.

By the 30-amp. switch, thirteen shorts were opened, see Fig. 4, from 600 to 17,500 amp., the times being: For 729 amp., 4.5 cycles; for 2170 amp., 2 cycles; for 7888 amp., 0.5 cycle; and for 3900, 4100, 9590 and 17,500 amp., 1 cycle. After the last opening, the contacts were burned so that the switch would not close and trip coils were badly distorted but the breaker had cleared the short at 17,500 amp.

The 60-amp. breaker opened seven shorts from 200 to 8500 amp., the final "shot" being at 9300 amp. when the contacts froze shut, Fig. 5. Overload coils were



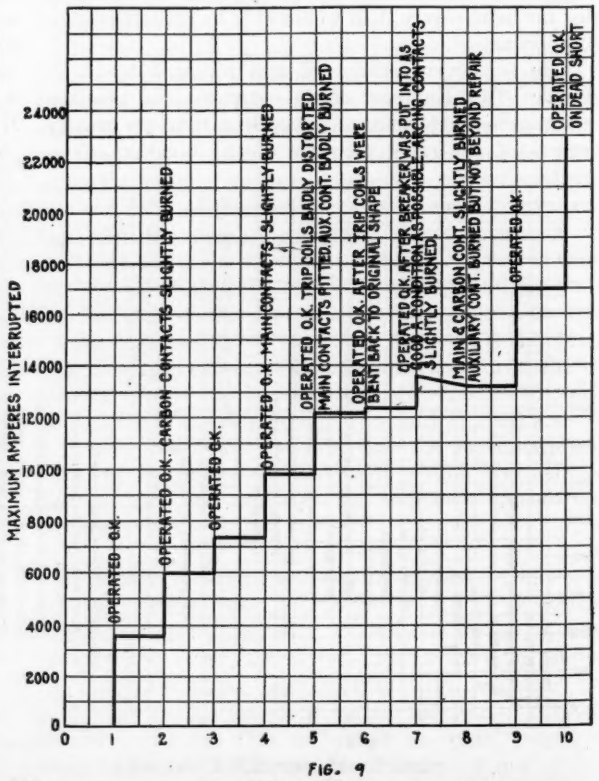

MAXIMUM AMPERES INTERRUPTED
OPERATED O.K.
OPERATED O.K. CARBON CONTACTS SLIGHTLY BURNED
OPERATED O.K.
OPERATED O.K. MAIN CONTACTS SLIGHTLY BURNED
OPERATED O.K. TRIP COILS BADLY DISTORTED MAIN CONTACTS REFITTED AUX CONT. BADLY BURNED
OPERATED O.K. AFTER TRIP COILS WERE BENT BACK TO ORIGINAL SHAPE
OPERATED O.K. AFTER BREAKER WAS PUT INTO AS GOOD A CONDITION AS POSSIBLE. ARCING CONTACTS SLIGHTLY BURNED
MAIN & CARBON CONT. SLIGHTLY BURNED AUXILIARY CONT. BURNED BUT NOT BEYOND REPAIR
OPERATED O.K.
OPERATED O.K. ON DEAD SHORT
FIG. 9

FIG. 8. ACTION OF 150-AMP.-220-V. BREAKER ON 440-V. TEST FIG. 9. 440-V.-150-AMP. BREAKER TESTS

badly distorted and contacts practically burned off, a condition not greatly to be wondered at after a 60-amp. switch had opened 5220 amp. three times and 8510 amp. three times. The 5220-amp. current was broken in 1.5 cycles and the 8510 amp. in 1 cycle.

Five shorts were opened by the 150-amp. breaker, the last four being of 11,000 amp. and opened in 1.5 cycles, Fig. 6.

440-Volt Test

For this voltage, three three-pole breakers were used with ratings of 15 amp. at 440 v., 150 amp. at 220 v. and 150 amp. at 440 v. The three poles of the breaker were strapped together, the switch closed and then the 13-kv. oil switch, the Urelite breaker opening the short. Current values were varied by means of grids.

Eight shorts were successfully opened by the 15-amp. switch, the maximum current being 7500 amp. and, at the end of the test the switch was in good condition, as shown in Fig. 7. Times of opening were: For 889 amp., 4.5 cycles; for 1297 amp., 2 cycles; and for 4130 and 6050 amp., 1 cycle.

On the 150-amp., 220-v. switch, eight shorts were successfully opened, Fig. 8, the greatest current being 11,800 amp. Only on a ninth test at 13,200 amp. was the breaker bested, one phase being burned up completely and the other two welded shut. For 1267 and 4250 amp., the opening was in 3.5 cycles; for 1720 amp., in 5.5 cycles; for 2350 and 2920 amp., in 3 cycles; and for 5869 and 11,600 amp., in 2.5 cycles.

Successful opening of ten shorts was made by the 150-amp., 440-v. breaker, the last one being at 22,950 amp., Fig. 9. Times of opening were: For 3575, 13,560 and 17,000 amp., 4 cycles; for 6050 amp., 5 cycles; for 7320 and 22,950 amp., 4.5 cycles; for 9930 amp., 7.5 cycles; and for 12,170 and 13,300 amp., 3.5 cycles. In spite of these excessive overloads, the breaker was in operative condition at the end of the test.

The tests showed that the arc is not entirely extinguished even when the current oscillograph shows zero value, as some records of voltage across the arc showed that zero voltage was reached three cycles after current had fallen too low to be recorded.

For safe rupturing, the 15-amp., 440-v. switch will act above 7500 amp.; the 150-amp., 220-v. switch up to 11,600 amp.; the 150-amp., 440-v. up to over 23,000 amp.; these values are for 3-phase service. For single-phase, i.e., a phase to phase short, the 15-amp., 220-v. switch will handle over 7300 amp.; the 30-amp., 220-v., 9900 amp.; the 60-amp., 220-v., 8500 amp.; the 150-amp., 220-v., over 11,000 amp.

The tests showed that for such severe use, overload coils should be braced between turns to prevent collapse and warping and that copper arcing tips might be improved, as the copper becomes soft and fails to make contact, but burned contacts can be renewed and the performance under the extraordinarily severe conditions imposed was a remarkable exposition of the capacity of this type of breaker and of the sturdy construction of the breakers tested.

Improvement of the Steam Boiler Industry*

By Geo. W. Bach

AT PRESENT, American boiler manufacturing is passing through a trying period, which might be called the Period of Elimination because of excess of boiler manufacturing capacity in this country.

In analyzing conditions, we find the causes for this excess to be centralization of power plants with consequent use of fewer and larger boilers operating at very high percentage of rating and high efficiency, also prime movers of high efficiency and better use of steam in process work. Other factors are development of water powers and use of oil and gas engines as prime movers, so that increase of boiler output has not been proportionate to growth of population or industries. These are natural developments and must be faced.

We should, however, follow the example of other industries in development of potential markets by trade extension; engineers should be shown that steel boilers are better than cast iron for heating, especially in larger plants such as institutions, factories and apartments. Modernizing of industrial power plants should be pushed in the interest of fuel conservation, for it is well recognized that, in 75 per cent of the boiler plants now operating, efficiency could be raised by amounts up to 30 per cent by replacing obsolete equipment with modern apparatus.

Industrial executives pay too little attention to the power houses of their plants and manufacturers of power equipment, boilers, stokers, pulverizing equipment, superheaters, economizers and other auxiliaries should get together to show the public that a tremendous saving can be effected in the production of steam power and heat.

One need only study the efforts of other industries such as the 40-per cent sales increase of paints and varnishes by the "Save the Surface" campaign, tenfold increase in the sale of "Sunkist" oranges, additional sales of 25,000,000 sq. ft. of plate glass and others to see what united effort can accomplish. Structural steel fabricators have started a 4-yr. program in the interest of increased use of steel in dwellings and other structures as against competing materials.

President Fish pointed out a year ago the low percentage of profit, if any, earned by boiler manufacturers. He suggested consolidation and elimination, but who is to be eliminated?

A first constructive move should be a census of the situation and development of potential markets. Then there should be definite systematized methods of doing business as to bidding on jobs, payments, guarantees and similar details. Sales effort such as proposed drawings, detail work, changes from standards to try to please everybody are expensive and are often duplicated by bidders, causing large economic waste in every boiler sale. Frequently the customer is not familiar with boiler and furnace standards, would willingly accept trade standards if they were made uniform and would

*From the President's address at the American Boiler Manufacturers' Ass'n Convention, Hot Springs, Va.

get more practical and efficient installations at lower cost. He would not then be the cause of upset in office and shop with the consequent troubles which invariably fall on the boiler manufacturer in his effort to keep a satisfied customer by furnishing special design and arrangement. Changes in design and construction with the coming of higher pressures make enough expense and obsolescence without adding trouble to suit the ideas of somebody who probably does not understand boiler practice.

One difficulty is lack of standardization along certain lines, so as to make one thing, make it good and at low cost of manufacture. Obviously shops equipped to handle heavy plate work of modern high-pressure boilers cannot, to advantage, make boilers of lighter plate and compete with shops having the lighter and faster tools suitable for lower-pressure boiler construction. Success that comes from specialization and standardization is well exemplified in automobile manufacture, from which a leaf may well be taken.

As to the future, I believe that there will be, before long, radical changes in boiler design and installation, for central station and large industrial plants, necessitating changes in shop equipment. Centralization of power is here to stay and superpower is more than a phrase. Whether this will continue exclusively in the lines of public service corporations or as centralized plants for a block of neighboring industries, supplying power, light and heat for those industries and leaving general public service for the central station is a question for the future but, in my opinion, the latter is a logical development.

Meantime, there is a larger field in modernizing the industrial power plant, both large and small, and in giving the steel boiler its proper place in the heating field. Small profit in the manufacture of high-pressure boilers and keen competition in the field of water-tube boilers make it unwise for shops equipped for light plate work to make the investment needed to equip for heavy construction.

Co-operation with the Department of Commerce in standardization and simplification is making progress toward betterment of fire-tube boilers. Like work for water-tube boilers is more difficult because of variations in design and conditions to be met but something might be accomplished as to design and shop practice.

To carry on the work properly calls for a trade-extension bureau which will analyze conditions, devise improved methods and advertise the steel boiler, so as to improve the industry for the help of makers and of the public in general.

In an address at the same convention, Charles F. Abbott, Executive Director of the American Institute of Steel Construction, told of the success of his organization in bringing the public to a better realization of the value of steel as a building material in comparison with other materials; also of economies realized as a result of revising and standardizing of specifications for structural materials and methods in co-operation with architects, contractors and public officials.

Mr. Abbott suggested that similar activities with enthusiastic backing by members of the A. B. M. A. would be helpful in improving methods and markets in the boiler industry and as a result would benefit the whole power field.

Power Costs for Government Plant

COMPARISON of government figures for cost of power from the Ontario Hydro-Electric Power Commission's system at Niagara Falls and from the privately owned plants in Quebec show that the horsepower developed by the hydro plant has cost 67 per cent more than the Quebec plants.

Figures given by the Toronto Financial Post are as follows:

	Private Quebec	Hydro Commission Ontario
Main primary hp.....	935,883	912,450
Capital	$156,552,616.00	$250,083,592.00
Capital per hp. developed	167.50	275.00
Gross revenue	24,120,323.00	36,856,113.00
Est. for taxes at 17 per cent for private companies in Quebec. Hydro and municipal tax free.....	4,100,000.00	.....
Revenue available for utility	20,020,323.00	36,856,113.00
Total kw-hr. generated	3,685,970,000	2,887,860,000
Revenue per kw-hr. generated in mils.....	5.45	13.2
Number employes	2,592	5,109
Kw-hr. generated per employe	1,420,000	560,000

Commenting on the figures, the Post calls attention to the greater investment per horsepower, the employment of 2½ times as many employes for equal power developed, lower revenue to private plants per kilowatt-hour. Commercial stations increased output in 1924 by 19 per cent and municipal stations only 9 per cent in all Canada. Power from the Hydro-Commission's system is not as cheap as that offered in other parts of the country and "the Commission is taking a wise course in purchasing efficiently developed power from a private corporation rather than undertake further heavy capital expenditures at this time."

The last statement is apropos of the plan to buy power from the International Paper Co. on the Gatineau River in Quebec and distribute it to industrial districts in Ontario, selling it on the same basis as current developed by the Chippewa plant at Niagara Falls.

UNDER certain conditions an air screen, or filter, on the air compressor intake is a necessity. Dust and foreign matter cause rapid wear and form a coating on the working parts of the machine. Various types of filters can be purchased though one may be made from a wooden frame box with removable panels. Panels should be covered with heavy half-inch mesh wire to which cheesecloth or a loosely woven flannel is tacked. The cloth will take up all heavy particles and when dirty should be renewed. Ample screen area should be provided. One square ft. of cloth for each 25 cu. ft. per min. free air capacity will be sufficient and will show no appreciable drop in pressure in the suction line.

Safety Demands Proper Stairs and Ladders

DESIGN, CONSTRUCTION AND USE OF PROPER FACILITIES FOR CLIMBING AND WORKING AT ELEVATIONS ARE NOTABLE FACTORS IN PREVENTING ACCIDENTS

MORE accidents are caused to the human race through its efforts to remain at all times in an upright position than from any other cause. Slipping and stumbling on sidewalks and floors are so common that they are given little or no attention except in case an injury results. The floors of many power plants are often found in a dangerous condition due to lumps of coal and firing tools left in the firing aisle of the boiler room, oil cans left "just inside the engine room door," racks for coats and overalls but a man descending a ladder so laden may easily be thrown to the floor.

No power plant can be a really safe place in which to work while there is one man employed there who disregards the rules of safety and fails to acquire the habit of looking for dangers to himself and especially to others. Nevertheless the design and arrangement of equipment can do much to prevent accidents and in the past ten years considerable thought has been given to the permanent stairways, ladders and elevated platforms

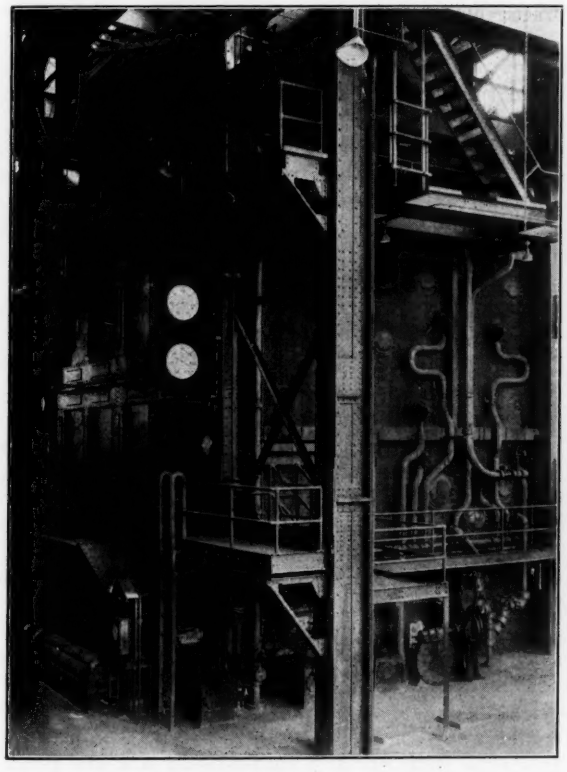


FIG. 1. WELL-DESIGNED STAIRWAYS, LADDERS AND PLATFORMS ARE ATTRACTIVE FEATURES OF THIS PLANT

FIG. 2. DOUBLE RUNGS ON THESE LADDERS GIVE COMFORTABLE FOOTING

meaning of course back of the opened door or to one side of the door opening, oily waste or drops of oil on the floor near the engine or shaft bearings. These conditions may be looked upon as minor until somebody is seriously injured; then a strenuous effort is made to change, immediately, the careless habits of the attendants.

Tripping and falling on stairs and runways are probably not so common as on floors but the results are liable to be so much more serious that greater attention should be given to the design, use and care of these parts of the plant. Stairs and ladders are intended as a means of ascending to or descending from an elevated position and should be used for no other purpose. Men who use stair steps as shelves upon which to put dinner pails, oil cans, shoes and the like, or even as seats are courting accidents. Ladders make convenient about power plants with a view to providing safe and convenient access to every device in the plant. The work of the National Safety Council is to be especially commended as it has resulted in codes of safe practices with which all power plant engineers should be familiar and which have been used freely in the preparation of what follows.

In present-day power plant construction, almost no consideration is given to the use of material that is not fireproof for building permanent stairs, ladders and platforms. Not only is the fire hazard too great but such material deteriorates and wears rapidly, thus in a short time repairs are continuously necessary and dangers are constantly presenting themselves.

Means for ascending and descending from one floor level to another may be divided into three classes, namely, ramps, stairs and ladders.

Ramps are commonly used where the grade is less than 20 deg. from the horizontal. Granolithic or cement walking surfaces are generally preferred in power plants, these being rough floated to obtain anti-slip qualities. Abrasive grit such as alundum mixed with the surface coat to the extent of 1½ lb. per sq. ft. of surface and an equal amount spread on before giving the rough float has many advantages. Four-inch wide strips of anti-slip tread are preferred by some; these strips are set 10 in. on centers in the cement at right angles to the line of travel and projecting less than ⅛ in. above the surface. Hardeners and trowelling should never be permitted and inclines should not be located where it will be necessary to cross them.

Safe Stairs Demand Proper Proportioning of Treads and Risers

When the grade is greater than 20 and less than 50 deg. from the horizontal, stairs are used, the standard dimensions of treads and risers being given in the accompanying table; winding stairs are not recommended. Stair climbing of any kind is hard work and if by proper design the stairs can be made less tiring accidents are less likely to happen. For this reason, the provision of a landing between floors is recommended. Long flights may be divided into approximately 12-ft. sections by landings to relieve tiring muscles. These landings should also be used at door openings as it is dangerous to have a door opening onto a flight of stairs. In all such cases the door should swing away from the stairway or the landing should be large enough to permit free passage when the door is swung open, and glass-paneled doors are essential for safety.

STANDARD DIMENSIONS OF TREADS AND RISERS

Angle of Stairway with Horizontal	Riser Inches	Tread Inches
28°—27′	6½	12
29°—25′	6⅝	11¾
30°—25′	6¾	11½
31°—26′	6⅞	11¼
32°—28′	7	11
33°—32′	7⅛	10¾
34°—37′	7¼	10½
35°—44′	7⅜	10¼
36°—52′	7½	10
38°—02′	7⅝	9¾
39°—12′	7¾	9½
40°—25′	7⅞	9¼
41°—38′	8	9
42°—53′	8⅛	8¾
44°—09′	8¼	8½
45°—26′	8⅜	8¼
46°—44	8½	8
48°—04′	8⅝	7¾
49°—24′	8¾	7½
50°—00′	8 12/16	7¼

In general practice stairs are designed to carry safely 100 lb. per sq. ft. Where, however, stairs are used as inclines for transporting machines of various kinds, the designer must take the service into consideration and make the proper safety allowance. The amount of head room also depends upon the service but should never be less than 7 ft., measured perpendicularly from the tread.

In proportioning the width of treads and height of riser care should be taken to have them uniform throughout each flight and to provide ample space on which to place the full length of the foot when descending without striking the heel against the riser above but not so wide as to compel an uncomfortable stride. One rule is to make the tread width (exclusive of nosing overhang) plus twice the perpendicular distance between tread surfaces equal to 25 in. The nosing overhang should increase the tread width ⅞ to 1¼ in.

Plain iron or steel plate should not be used for stair treads as they may cause slipping at any time. Marble, slate, wood and similar materials are safe under normal conditions but mud, oil or wear makes them slippery and unsafe. Gratings of abrasive metal, iron abrasive, lead abrasive, asphalt mastics and cork treads are of the anti-slip type and remain safe for long periods even under severe traffic. Concrete treads with easily replaced anti-slip tread inserts to prevent people from slipping and prevent the nosing from chipping are used in many plants. Concrete treads roughened by floating abrasive crystals into the surface will prove safe and practicable in many locations.

That part of the tread which projects beyond the top of the riser is called the nosing and is designed to prevent the back of the heel of the shoe from coming in contact with the riser when the wearer is descending a stairway. The nosing should be rounded on the under side to prevent the shoe from catching when ascending. These precautions are important safety provisions.

Risers should be provided on power plant stairs to prevent the toe from going back of the tread and injuring the leg by striking it against the tread above. Another safety provision, quite important for open stairs, is toe-boards placed along the sides of the stairways to prevent slipping off the end of the tread. These should extend at least 3 in. above the nosings.

Hand rails are essential to the safety of people using stairways. They are provided on both sides of all open stairways, regardless of width; even closed stairways over 3½ ft. wide should have hand rails on both sides fastened about 3 in. from the wall and those over 7 ft. wide should, in addition, have a hand rail in the center. The height recommended is 42 in. from the center of the tread to the hand rail, which for the average adult is above the center of his weight. The rail should be sufficiently strong to take up the force of impact of a falling man. In open stairways an intermediate rail should be provided and where stairs are used for carrying materials, netting covering the space between the hand rail and the toe-board is a wise precaution. Piping seems to be the most popular material for railings. Steel or iron angles will also serve the purpose.

Lighting of stairways is an extremely important feature. There should be sufficient light on the stairs at all times that they are being used. Artificial lights should be so placed as to throw light upon the steps and not into the eyes of those using them. Particular attention should be given to the lighting at landings and at the beginnings of stairways. Confusion as to the exact location of a stair tread has caused many accidents and certain designs of stair gratings have the nosing of different design from the rest of the tread to prevent such confusion.

Stairways ending in the proximity of machinery should have a detour guard placed around them to direct people away from the hazard.

When the grade is 50 deg. or more from the horizontal the use of ladders is necessary and when they are for permanent use they should be made of iron or

steel. The clearance space back of the rungs should never be less than 6½ in. but 8 to 12 in. is preferable, in front of the ladder a minimum of 36 in. is recommended, and at the sides a continuous clearance space of at least 15 in. on each side of the center line of the ladder is required by the code of the American Society of Safety Engineers.

In using ladders, the rule should be that only one man should be on the ladder at a time. Ladders should, of course, be kept in perfect repair and painted at frequent intervals to prevent rusting. Always face the ladder when ascending or descending and do not attempt to go up or down a ladder without the free use of both hands. Materials should be handled with a rope. Safety belts and hooks should be used when the character of the work demands the attention of the workman or constitutes an element of danger.

Ladders for scaling the side of a wall, tank or stack are frequently made of U-shaped sections imbedded into the wall. A far better arrangement, however, is to have the ladder built with side rails fastened at top and bottom, with additional supports between to give necessary rigidity and strength. Where U-shaped sections are in use, a safeguard to prevent the foot from slipping off can be made of a lightweight steel bar clamped to each side of the ladder. Side rails of angle steel or iron for ladders should be not less than ½ by 2 in. The rungs of the ladder should be of uniform section throughout the entire length, ⅝-in. diameter seem to be preferred, and the spacing should also be uniform, 15 to 18 in. representing general practice.

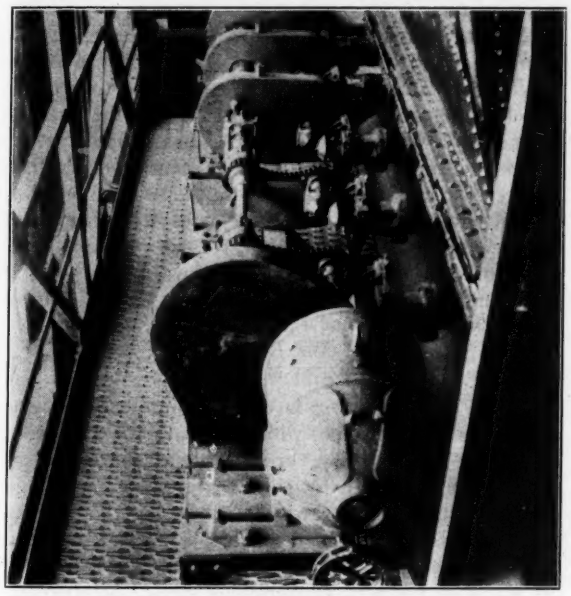


FIG. 3. A WELL-DESIGNED PLATFORM WITH RAILINGS AND TOE-BOARD

Splicing plates should be of the same size and material as the side rails and carefully riveted or bolted to the outside of the rail. When over 20 ft. in length ladders should be built in zigzag section and provided with safety platforms unless cages are used. Rungs should be omitted above the work level and the side rails carried 3½ ft. higher, ending in a gooseneck. The open space back of the ladder at landings should not exceed 18 in.

For permanent ladders 20 ft. or more in length a basket or cage guard should be provided extending from the top of the ladder to within 7 ft. of the base with the bottom flared 4 in. or the portion of cage opposite the ladder carried to the base.

Modern Plants Use Runways and Platforms

During recent years, with the increasing height of boilers, has come more general use of elevated runways and platforms giving convenient access to all parts of the boilers, control valves in pipelines and coal and ash conveying equipment. Especially constructed grating has grown in use because of its anti-slip quality and rigidity, as well as the fact that it permits light to pass through to the space below without much interference and dust does not collect upon it as it does upon a closed floor.

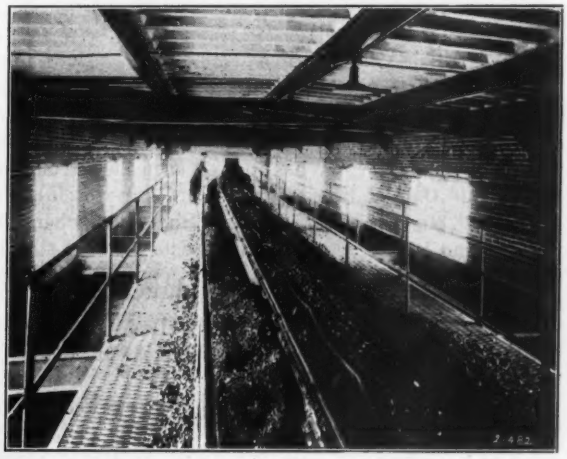


FIG. 4. GRATING MAKES EXCELLENT FLOOR FOR COAL BUNKER RUNWAYS

All platforms and runways should be strongly constructed and carefully railed around open spaces. These are conveniently made of piping similar to that used on stairways. At least two rails should be used, one at 42 in. and the intermediate about 21 in. above to floor level. In addition, a toe-board is an essential safety precaution to prevent the foot from slipping out beneath the railing or the accidental pushing of tools, boards or other things off the platform to the floor below.

Above all, safety in the use of stairs, ladders and platforms requires a clear-thinking, level head. Dizziness, sleepiness, absent-mindedness, ill-fitting or dirty glasses, hob-nailed shoes or shoes with iron plates, loose, flopping clothing are conditions and equipment which should be avoided at all times around power plants and particularly when using stairs, ladders and platforms.

Between Michigan City and South Bend, Ind., the last link in the 132,000-v. transmission line that connects the Chicago power district with parts of Ohio, Virginia, Kentucky, West Virginia and Pennsylvania, has recently been completed.

New York Has Largest Automatic Hydro Plant

SOFT MAPLE DAM STATION OF NORTHERN NEW YORK UTILITIES, INC., CONTAINS TWO 9375-KV.A. UNITS WITH COMPLETE AUTOMATIC CONTROL. BY J. F. SPEASE*

AT ITS SOFT MAPLE DAM development on Beaver River, near Watertown, N. Y., the Northern New York Utilities, Inc., have recently put in operation the largest completely automatic hydro-electric generating station ever built. In this station there are two General Electric vertical waterwheel generators, rated at 9375 kv.a. each. The record for size was previously held by the G. E. 7000-kv.a. unit installed by the Adirondack Power & Light Corp. at its Sprite Creek development.

This automatic station, shown in Fig. 1, is situated 6 mi. from the Taylorville switching station of the company. Fifteen other hydro-electric stations feed their output into this switching station; one of these is automatically controlled. When power is needed from the Soft Maple Dam station it is necessary only to close the breaker at the switching station. Similarly, when the power is no longer required, the breaker at the station is opened. The generators can be operated singly or together in this manner.

Across the Beaver River, an earth-filled dam has been built, giving the station an operating head of 121½ ft. This head operates two 10,500-hp. I. P. Morris vertical waterwheels, which in turn drive the two generators. The latter are General Electric Co. ATI generators, rated at 9375 kv.a., 32 pole, 225 r.p.m., 6600 v., 3 phase, and 60 cycles. With each there is a 60-kw., 125-v., direct-connected exciter. Figure 2 shows the generating units as installed.

Current from each generator goes through three single-phase, 3125-kv.a. transformers, Fig. 3, and is stepped up from 6600 to 110,000 v. before transmission to the Taylorville switching station. From the latter station it is fed into the main transmission lines of the company at 110,000 v.

SEQUENCE OF OPERATION

Because of the relatively large amount of energy supplied by these generators, the equipment is so arranged that full load is not put on the line for slightly more than a minute. The station is equipped with an automatic voltage regulator and with a float switch, governed by the amount of water behind the dam. The latter is a protective device only, since operation of the station is manually controlled at the Taylorville switching station by means of a control circuit. The operator determines when the power from the Soft Maple Dam station is needed and cuts in the station or takes it off at will.

The sequence of operation of one unit is explained in the accompanying diagram, Fig. 4, showing the elementary wiring of the station. The control power transformer, No. 11, is connected through suitable fuses to one phase of the a.c. line to provide power for operating the various devices. The secondary side of the transformer is controlled by a double-pole, single-throw lever switch, No. 8. Device No. 1 is the master starting element.

Normal starting sequence, once the master starting element, No. 1, has been actuated, is briefly as follows. The various protective devices and the control power switch are closed; all other devices are in the "starting positions." When the starting element closes, it completes a circuit which energizes the master control contactor, No. 4, causing it to close. The closing of the control contactor in turn completes a circuit which energizes the governor solenoid, No. 65. This opens the governor pilot valve, causing the governor to open the gates and starting the waterwheel.

GENERATOR IS CONNECTED TO LINE BY SELF-SYNCHRONIZING METHOD

While the generator is entirely automatic in operation, the principle on which it works is simple and effective. The opening, or closing, of the waterwheel gates is accomplished by a Woodward waterwheel governor. While the waterwheel is bringing the generator up to speed, the exciter field rheostat is short circuited to permit the rapid building up of the exciter voltage. At about 95 per cent synchronous speed, the speed con-

*Central Station Engineering Dept., General Electric Co.

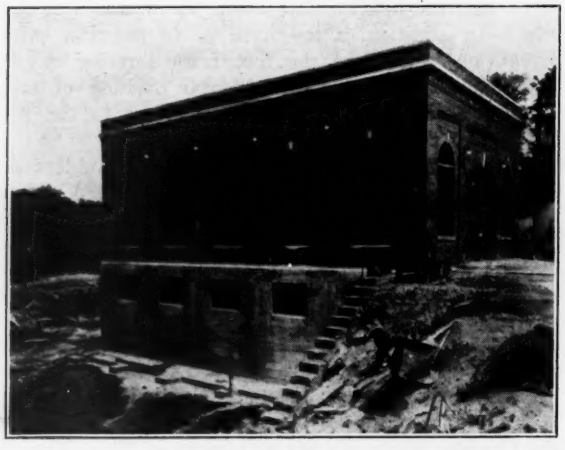


FIG. 1. EXTERIOR VIEW OF SOFT MAPLE DAM STATION NEAR WATERTOWN, N. Y.

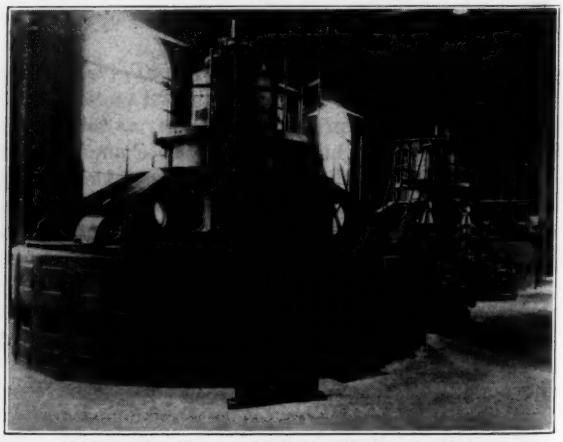


FIG. 2. TWO 9375-KV.A. GENERATING UNITS ARE AUTOMATICALLY CONTROLLED FROM SWITCHING STATION 6 MI. AWAY

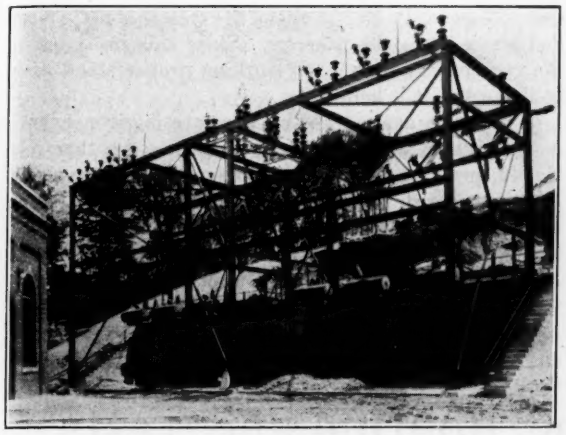


FIG. 3. TRANSFORMERS STEP POWER UP FROM 6600 TO 110,000 V. FOR TRANSMISSION TO SWITCHING STATION

trol switch, No. 13, closes, completing a circuit which closes the oil circuit breaker, No. 7, connecting the generator to the line without field.

Closing of the oil circuit breaker completes a circuit which causes the field contactor, No. 44, to close, putting field in the generator. As soon as field is thus applied, the machine is pulled into step by the combined effect of its synchronizing capacity and the acceleration of the waterwheel to normal speed. The generator quickly builds up to normal voltage, as determined by the voltage regulator, No. 90, and the machine will take load as determined by the setting of the governor.

In shutting down normally, when the master element, No. 1, is opened, the control contactor, No. 4, opens, de-energizing the governor solenoid relay, which causes the gates to close. A limit switch is operated from the gates and is so adjusted that when the gates reach a position that will reduce the load on the generator to a low value, a circuit is completed to open the oil circuit breaker, No. 7, disconnecting the generator from the line. The opening of the oil circuit breaker breaks the circuit of the generator field contactor, No. 44, which opens, taking the field off the generator. The station is then on its normal shutdown position, ready to repeat the starting sequence.

In case the station is shut down by opening the high tension line in the controlling station, the underload relay, No. 37, closes its contacts and energizes the time relay stopping device, No. 3, which in turn opens its contacts and de-energizes the control contactor, No. 4. The rest of the stopping sequence is the same as that just described. In this case the station can be started again by closing the high tension line, thus energizing the control power transformer, No. 11. The switchboard carrying relays, regulators and meters mentioned above is shown in Fig. 5.

Soft Maple Dam automatic station is provided with all customary protective features, including protection against overspeed, underspeed, alternating current overload, field failure, hot bearings, overheated machine windings, excessive alternating current voltage, low oil pressure, exciter overvoltage, and shut down on momentary alternating current undervoltage.

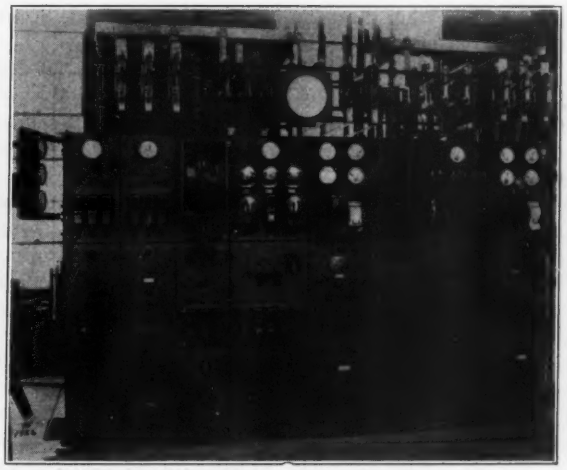


FIG. 5. SWITCHBOARD CARRIES FULL COMPLEMENT OF METERS AND AUTOMATIC DEVICES

The overspeed limit switch, No. 12, opens the master control circuit of contactor No. 4 and shuts down the machine in case of overspeed. When the speed has been reduced to 80 per cent normal, switch No. 12 recloses, allowing the machine to start again.

Underspeed protection is provided by a centrifugally-operated circuit closing switch, No. 13, whose contacts remain open until the machine reaches approximately 95 per cent synchronous speed. Since it completes the circuit of the exciter relay, No. 53, the machine cannot be connected to the line until it attains approximately synchronous speed.

Protection against alternating current overload is afforded by overload relays, No. 28, which are connected to current transformers in the power lines. This relay must be set by hand before the machine can be started again.

If the field current fails, a field relay, No. 30, is de-energized. Its contacts close the circuit of a time delay auxiliary relay, No. 30X, which opens the control circuit of the contactor No. 4 and shuts down the station. This also must be reset by hand. The use of the time delay

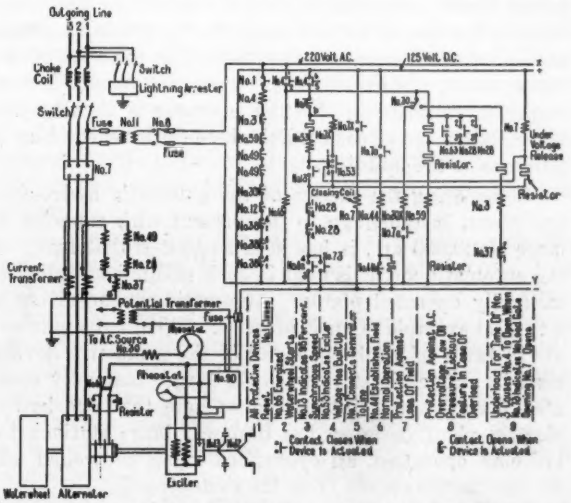


FIG. 4. ELEMENTARY WIRING DIAGRAM OF AUTOMATIC SWITCHING EQUIPMENT FOR ONE UNIT

prevents shutting down on low fluctuations in field current caused by system disturbances.

If the temperature of the bearings reaches 90 deg. C., a bearing temperature relay, No. 38, opens the coil circuit of the master control contactor, No. 4. Resetting must be by hand, preventing restarting until an inspection has been made.

Machine temperature relays, No. 49, protect against overheated windings, due to a moderate overload being continued too long. When the temperature has dropped sufficiently the machine will start again. The relay also prevents running too long on single or badly unbalanced phases.

In case of excessive alternating current voltage the overvoltage relay No. 59 opens the master control circuit and shuts down the machine. Since this indicates that the voltage regulator is not working properly and should be inspected, it is hand reset.

Protection against low oil pressure is given by relay No. 63, which shuts down the machine. Another relay, No. 45, provides protection against exciter overvoltage.

Lightning or other bad disturbances may cause momentary alternating current undervoltage, causing contactor No. 4 to open but not disconnecting the machine from the line because the oil circuit breaker, No. 7, is not tripped until the gate is closed. This last operation requires several seconds. In the meantime the a.c. voltage reaches normal, and contactor No. 4 closes again.

Hydro Plant Operating Routine and Tests

Organization of Force, Keeping of Records and Layout of Operating Schedules Must Be Considered

OPERATION OF hydro-electric plants has in recent years aroused much discussion because such plants are often tied in with large power systems and proper operation of them as units in the larger system introduces many variable factors. The actual performance of the hydro-electric generating units themselves seems to be pretty well standardized as far as the operators are concerned. The general method of operating a plant, however, to take advantage of the water flow, to produce maximum kilowatt-hours, to divide the load between several units, or to carry base load or peak load of a system, is of vital importance in justifying the investment in a hydro-electric plant.

Organization of Force Hard to Standardize

Organization of a hydro plant force is necessarily more simple than that of a steam station. It is determined largely by the location, arrangement of units, design of plant and its relation to the system and it is almost impossible to specify an exact form of organization, as no two can be exactly alike.

In manually-operated stations it is common practice to have one man on each of the different levels of the power house: switchboard gallery, main floor and basement in the case of vertical turbines, for which oil pumps and other auxiliaries are often located at the level of the water wheel. With horizontal units, the basement man might be eliminated. A chief operator is usually provided, in charge of each shift, whose duties carry him to all parts of the building.

Considering the success of the automatic hydro-electric plant, installed up to the present with capacity as large as 20,000 hp., it has been suggested that many of the automatic methods used in such plants be applied to manually operated plants. Automatic synchronizing is a typical example of such practice. Then, too, engineers are in favor of applying many of the protective devices used in automatic stations to the larger manually operated plants. It is interesting to note that one hydro-electric plant designer has designed large stations for one-man operation, all operations being controlled and all observations made from the switchboard.

One of the most important functions of the operators in any hydro-electric plant is the keeping of adequate records and the performance of inspection and maintenance work. Operating records, besides the usual data taken from meters and notations of all that transpires in the station, should include records of flow through turbines, flood gates, spillways and the like, data on the water conditions upstream from the plant. All this information can be gathered by the plant operators at little or no cost. This process of getting the information is of value to the operators, too, in keeping them alert. In normal operation the operators may not have much to do, a condition that has a bad psychological effect and tends to establish a sluggish mental attitude from which they do not always recover quickly in an emergency.

Record sheets should contain only important readings and the forms should not be complicated. One station of medium size uses a letter size sheet ruled for hourly records of water, kilowatts of main units and per cent gate opening, cycles, power factor, exciters, transformers and floodgates. At the top are given forebay and tailrace readings, the difference between them being the effective head. Total kilowatt-hours for each hour, together with station voltage, are plotted as a block curve across the sheet, the scales for these being on the right hand edge of the sheet. Total output for 24 hr. is recorded, together with maximum kilowatt-hours for any particular hour during the day and maximum indicated kilowatts (maximum kw. time) at any particular instant; average load and load factor, obtained by dividing average load by maximum kilowatt time. Average flow of river is recorded and converted into available capacity in kw-hr., as will be explained. Available capacity of power house is shown in kw-hr., found by figuring the capacity of the installed units at the average head for 24 hr. Finally, kw-hr. lost are found by taking the difference between available capacity of river and what was actually generated by the machines.

Important notes of operation are entered on the back of the log sheets and these notes, together with certain of the records are entered in a log book kept on the operator's desk for reference. Weather conditions and temperatures are recorded four times daily and a rain gage is read every 24 hr.

Such records as the above, combined with analysis of

river flow upstream, are of great help in operation, since they often make it possible to draw down upper pool levels by heavy operation when a rise in the river is approaching. The operators should, of course, check each predicted rise against the actual rise, thus educating their judgment and evolving a formula for such predictions.

Inspection and Maintenance Work

Organization of inspection and maintenance work is extremely difficult since it must depend on the number and relative size of plants in a system, on their location with respect to load centers or distributing points, on the company personnel and on many other factors. Such work, it is generally agreed, should be done during the low flow season or, if there is none, during the time of least load demand.

One company operating 24 hydro-electric plants, has a centralized inspection department. Semi-annual inspections of plants are made by a regular inspector who reports to the main office and works in conjunction with the division superintendent and plant foreman. Changes recommended by the inspector to improve operation are noted and if conditions are found that need immediate attention, the inspector notifies the load dispatcher and the division superintendent.

In another company the essential feature is that after the department heads have determined what inspections are to be made and how often, the statistics department sends out notices of inspections due, follows up and receives the reports and files the results.

Various Tests Determine Water Flow Through Turbines

Mention has been made above of the value of a knowledge of the relation between kilowatt output and water used by the turbine in giving that output, which is a measure of its economy. It has been found that not many plants secure data on water flow. Among the methods used for measuring this flow are: Venturi meter, weir, salt solution, screen, color, velocity, Pitot tube, current meter, salt velocity and Gibson method. All but the last two are fairly well known; the Allen salt velocity method and the Gibson method are of recent origin and have proved so successful and accurate that they are coming into extensive use.

The basis of the Allen method is the fact that salt in solution increases the conductivity of water. Salt solution is introduced near the upper end of the conduit that leads water to the turbines and the passage of the solution across one or more pairs of electrodes at other points in the conduit is recorded graphically by electrical recording instruments. The discharge in cubic feet per second equals the volume in cubic feet (measured) divided by the time in seconds for the solution to pass the two points.

The Gibson method is based on Newton's second law of motion that force equals the product of mass and rate of velocity change and its corollary that the relation between the change of pressure and change of velocity of a water column can be expressed in terms of the pressure waves that are propagated. By stopping the flow in a penstock by closing the waterwheel gates gradually in a given time. The pressure-time diagram is secured by the Gibson apparatus; it is measured and related to known conditions. The result is the rate of flow in the conduit at the time closure began.

The results obtained with the two methods just noted have proved so precise that they emphasize the necessity for attention to all details of hydro-electric plant tests. Electrical measurements are made so easily that precision of these measurements is not always given attention, by calibration of instrument transformers and attention to other details.

Power-Discharge Curves Form Basis for Operating Schedules

From tests such as the above, it is possible to calibrate the generating units in a plant as water meters, curves for such use being shown in Fig. 1 for different heads. Once such tests have been made and the results plotted they can be used to obtain a daily record of water consumption and to prepare power-discharge curves for

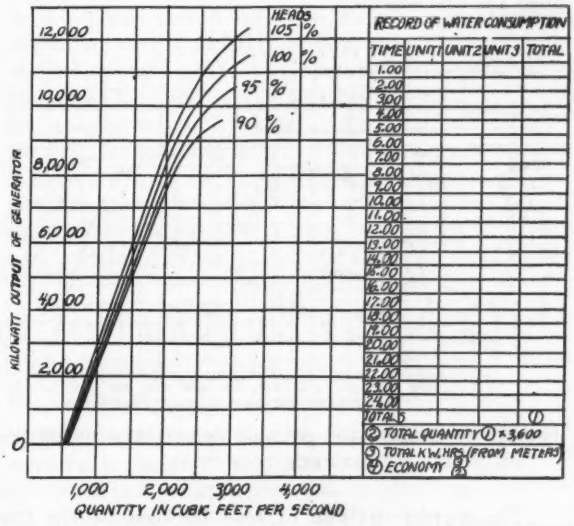


FIG. 1. CALIBRATION CURVES OF WATER-WHEEL DRIVEN GENERATOR AS A WATER METER

proper division of load among the units for economy. This method of recording water consumption cannot be used, of course, to observe the loss of efficiency of the water wheels. This loss must be checked up as often as necessary, usually when major repair or important changes are made and new calibration curves prepared.

Operating schedules showing proper division of load among several units are of great convenience to the operators and can be obtained once we have the calibration curves.

In plants containing units of exactly the same size and design, it can readily be shown that the total load should be divided equally between all units in operation. Where the units are of different sizes and of different characteristics, the problem is a little more complicated. Figure 2 will serve as an example of a plant containing two units, one of 44,000 kw. capacity with low-speed type runner and the other unit of 26,000 kw. capacity with a much higher speed type runner. It is not at all probable that two such runners would be used in the same plant, but this example is chosen to give curves of different appearance so that the readings may be readily differentiated.

From the power-discharge curves C_1 and C_2, new curves, B_1 and B_2, are plotted of kilowatts per cubic foot per second. Then the first derivative of each power-discharge curve is drawn, this being expressed mathematically as $d\text{kw} \div dq$ and defined as the rate of gain in power to increase in discharge. These curves A_1 and A_2 are actually curves representing the tangents of the angles of slope of the power-discharge curves. If a series of horizontal lines is drawn on this diagram, the intersection of each line with the two derivative curves will give the correct division of discharge and load between the two units for best economy.

For example, a horizontal line at 24 on the vertical scale intersects A_1 at 1520 cu. ft. per sec., corresponding to a load of 35,800 kw. and intersects A_2 at 1003 cu. ft. per sec., corresponding to a load of 23,200 kw. This gives the correct division of a total load of 59,000 kw. and a total flow of 2523 cu. ft. per sec. between the two units for best economy.

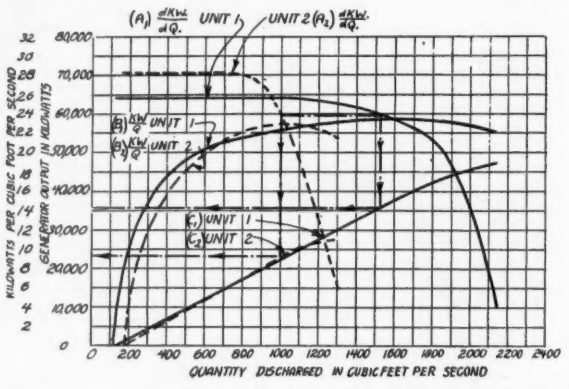

(A1) dKw/dQ UNIT 1
UNIT 2 (A2) dKw/dQ
(B1) Kw/Q UNIT 1
(B2) Kw/Q UNIT 2
C1 UNIT 1
C2 UNIT 2
KILOWATTS PER CUBIC FOOT PER SECOND
GENERATOR OUTPUT IN KILOWATTS
QUANTITY DISCHARGED IN CUBIC FEET PER SECOND
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
0 10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000

FIG. 2. DETERMINATION OF ECONOMICAL DIVISION OF LOAD BETWEEN TWO UNITS

The correct division of load between two or more units in a station may therefore be stated by the following theorem: The load should be so divided between two or more units so as to obtain equal values of the first derivatives of the power discharge-curve of each unit. From a series of horizontal lines drawn on this diagram, a table is prepared for the operator's convenience to show a correct division of load.

For division of load among several units of different sizes or types, this process can be extended and an operating schedule tabulated for combining various units to carry a given load. For different heads, separate schedules must be worked out.

IF INDUSTRIAL safety simply meant the saving of some 23,000 lives annually and the elimination of a few million non-fatal injuries, the movement would neither have reached its present development nor justified the hopes for the future, avers Arthur H. Young, past president of the National Safety Council. Safety in industry actually means far more than the average industrial leader realizes. It is directly correlated on the one hand with efficiency and economy of production and on the other hand with the establishment and maintenance of proper relations between employers and employees—and these two are probably the most important problems facing any American industry today.

Pipe Line Refrigeration Systems

GENERAL CONSIDERATIONS IN INSTALLING AND OPERATING THEM AND IN MAKING RATES FOR SERVICE

IN THIS COUNTRY there are two general systems of pipe line refrigeration, those circulating ammonia and those circulating brine as the refrigerating medium, the latter system seeming to be preferred by the majority of those engaged in this work. Pipe line refrigeration has its most general application in the market districts of large cities, sometimes in connection with large cold storage warehouses; the latter forms a desirable combination. Since the greatest item of expense in most cases is power, this condition provides a large number of cubic feet of space cooled in proportion to the cost of the distributing mains and minimizes the cost per ton of refrigeration.

In designing pipe line plants, it is well to consider the general direction and rate of growth in the district to be covered, so that mains may be installed to care for the future. It is also well to consider whether there is a market for low pressure steam for heating or process work.

PRECAUTIONS WHEN PURCHASED POWER IS USED

Where the central refrigerating plant obtains power from a public utility company, as several of them do, various forms of maximum demand charges are made. For this reason, it may be advisable to use synchronous motor-driven compressors equipped with clearance pockets so that they can be unloaded, to permit closer regulation according to system demands and to operate at the highest possible suction pressure. With variable speed motors or steam engines driving the compressors, this is not necessary. When using central station power, it is important to have duplicate feeders enter the plant and ample transformer capacity, as a precaution against shut-down.

METHODS OF INSTALLING PIPE LINES

Pipe lines for handling brine and methods of controlling them are of the greatest importance in any central refrigerating system. The pressures involved will be determined, of course, by the length of the lines and the provisions made for increase of business and change of load. In one large system, brine is circulated through four 12-in. mains making a dual system to take care of emergencies. These mains are full weight wrought iron pipe with flanged joints and ring gaskets. Alternate joints are made with heavy cast-iron sleeves and calked with lead. Corrugated expansion joints take care of the initial pipe movement. These mains are laid from 4 to 7 ft. below street level, two mains, one the feed and one the return being laid beside each other. They are supported on 4 by 12 by 36-in. creosoted blocks and each main is insulated with three layers of 1-in. hairfelt with hairfelt fill in the space between the pipes.

Care must be used in any brine system to prevent brine losses. In the system just described, about one-half barrel of brine a day is lost and the losses over which the distributor has no control are about double this amount. Specific gravity of the brine is kept at about 1.23 and the solution is tested frequently and

kept slightly alkaline. Some of these mains have been in service for 25 or 30 yr. and no trouble has been experienced with deterioration of them.

It has been found that control of brine lines by motor operated, remote controlled valves is of the highest value in preventing losses of brine and shut-downs in case of a break. With these valves, controlled from the main compressor room, the system can be sectionalized in somewhat the same fashion as electric transmission lines. In case of a leak, the section in which it is located is indicated by loss of pressure on the gages of that section and little time is lost in getting the other sections in operation. Such motor-operated valves should be provided with the usual safety devices to prevent the valve from breaking in case of an obstruction on its seat.

Complete Data Needed to Establish Rates

Full data on operation of a pipe line system are necessary in order to determine costs and compute rates for service. Such items are tons of refrigeration delivered to the system, cost of power per ton, costs of brine pumping and the like should be obtained. To do this, suitable instruments must be installed and read carefully and regularly by the operators. In the case of ammonia circulating systems, the recently developed liquid ammonia meter has been found to provide a direct and accurate method of measuring pounds of ammonia circulated and from this the plant tonnage.

Methods of fixing rates for service and applying them will differ, of course, with each different pipe line refrigeration system, just as they do in electrical or district heating systems. In refrigeration, the situation is further complicated by the methods of measuring service. To measure accurately refrigeration service to individual cooler boxes, so as to charge for tons of refrigeration, a recording flow meter would have to be used to determine the quantity of brine used and a recording thermometer or temperature differential instrument to measure the temperature difference. In many cases, this temperature difference might be only a few degrees to give proper circulation, especially in a small box and the commercial instruments might have a large percentage of error with such a small difference. Furthermore, such instruments, together with their maintenance, are costly, especially for small boxes. One company has avoided this difficulty in a practical way by making a charge based on cubic feet of space refrigerated, making a distinction between a freezer and a cooler. A minimum demand charge for 4 mo. is made, after which the service is charged monthly and is optional.

In a system served by pipe line refrigeration, continuous and reliable service must be maintained, as there are usually many perishable materials, foodstuffs and the like, to be refrigerated. For use in an emergency, a reserve storage of brine should be kept at low temperature, ready to put into the system to make up losses. Some systems have been run for years without a serious shut-down.

Dual Evaporation System for CO_2 Refrigeration

New Type of CO_2 Compressor and Condenser, Employing Dual Evaporation and Compression Principle, Is Described at N. A. P. R. E. Meeting. By Charles H. Herter

BEFORE A RECENT joint meeting of the New York Chapters 1 and 2 of the N. A. P. R. E. and the New York Section of the A. S. R. E., an important lecture was given by J. C. Goosmann of Chicago. In the first part of the lecture the historical foundation of refrigeration, and the fundamental law of gases and of heat were interestingly reviewed. The successful liquefaction of the gas helium by Prof. K. Onnes of Leyden University, Holland, in 1908, was noted. In this case liquid hydrogen was evaporated at a temperature of —457.3 deg. F. Aiming to solidify helium, Prof. Onnes worked hard for ten years more and reached a point only 1.6 deg. above absolute zero of temperature.

In 1839, J. K. Mitchell produced a temperature of —146 deg. F. by absorbing ether in carbon dioxide snow and reducing the vapor tension of the mixture by the use of a vacuum pump.

Use of Carbon Dioxide Refrigeration Increases

While ammonia is recognized as the most widely used refrigerating medium, conditions are arising in which carbon dioxide is preferred chiefly because of its harmless nature and because it is superior for low temperature work. In many situations safety is the most important consideration. The objection raised heretofore against its low critical temperature, 88.43 deg. F., beyond which very little refrigeration was thought to result, has been largely overcome by the recent development of the dual method of evaporation described below.

The speaker explained in detail the presence of CO_2 in nature which is as common as is air and continually regenerates itself. The process of manufacturing CO_2 synthetically from pure coke and limestone was described and illustrated.

Next CO_2 was shown in use in the usual standard compression system of refrigeration, employing a compressor, condenser, expansion valve and an evaporator such as a brine cooler. The three chief refrigerants, NH_3, CO_2 and SO_2 (sulphur dioxide) were next compared with each other. Thus, at atmospheric pressure the evaporating temperatures are —110 deg., —28 and +14 deg. F. respectively. On the other hand, the latent heat of evaporation at atmospheric pressure is respectively 589.3, 256.3 and 172. The specific heat of the liquid is about 1.12, 0.75 and 0.34. While the condenser pressure with CO_2 is around 1000 lb., the ratio of compression is only 1 to 3.23, as against 1 to 8 with ammonia. The piston displacement required with CO_2 is much less than with NH_3 and this compensates for its higher discharge pressure.

Dry Ice (CO_2 Snow)

Experiments at the test plant of the York Mfg. Cc., with which Mr. Goosman is connected, have shown CO_2 to congeal at —75 deg. F. and 50 lb. gage pressure, consequently the compressed liquid cannot be poured out like liquid ammonia or even liquid air. The demonstrator tied a piece of chamois leather around the outlet nozzle of a common 50-lb. cylinder of carbon dioxide, donated by the Liquid Carbonic Co., then he opened the

valve slightly and allowed the gas to flow in the leather bag for about one minute. Immediately the bag became filled with a ball of CO_2 snow at a temperature of —110 deg. F., a perfect imitation of regular snow, except much colder, so that it could not long be held in the bare hand. When thrown into a glass of water, it acted like snow, but showed less cooling capacity. Exposed to air the snow did not melt to a liquid but evaporated slowly, because the film of CO_2 gas enveloping the ball of snow retards the transfer of heat.

Dual System of Evaporation

The experiments of Louis Cailletet in 1877 showed that the discharge of a compressed gas into a region of lower pressure deprived its own liquid of heat. Consequently it is also possible partially to liquefy compressed CO_2 above its critical temperature and thus to convert it into an effective refrigerant, in spite of the old theory that it yields only the cooling effect of a compressed and cooled gas expanding against resistance.

This scientific discovery has since been embodied in various methods and arrangements. Windhausen, among others, patented in 1902 a method whereby the liquid is cooled in a special intermediate liquid receiver. The vapors generated during the cooling of the liquid are conducted into the suction port of a high pressure compressor. The sub-cooled liquid passes on to the low pressure evaporator where it performs low temperature refrigerating work, and the evaporated gas is returned to a low pressure compressor. It will thus be seen that in this method two compressors are used.

In general, the dual system as usually employed includes all parts of the old compression system and, in addition, a liquid cooler and regulating valve in the liquid pipe from condenser to liquid cooler. The vertical CO_2 compressor has the usual suction inlet at bottom for low pressure suction vapor, and above that an extra port for high pressure suction vapor, this being the vapor from the liquid forecooler.

A new style vertical and coil type of CO_2 condenser is used, the gas passing centrally in a pipe up to top of shell where it is sprayed over the coils. The early formation of liquid on the outside of the cooling water coils keeps the greater part of the cooling surface moist for energetic heat transfer, without interfering with the entry of new gas to be liquefied. There are three closely wound helical coils within the shell, each of the same surface. This is attained by letting the innermost coil assume the diameter of the outer coil after 50 per cent of its travel upward and by letting the innermost coil expand to the largest diameter after it has covered 50 per cent of its length from top down. The center coil does not change its diameter. In this manner high velocity for both gas and water is obtained, therefore a high rate of heat tranfer per square foot.

When the warmer liquid enters the shell of the liquid cooler under suddenly reduced pressure, a portion of the liquid boils and cools the remainder to a temperature corresponding to the reduced pressure, because it cannot obtain heat from outside, the shell of cooler being well insulated. Thus, Cailletet's experiment is duplicated and liquid entering at a temperature above the critical is successfully cooled and made effective for refrigeration.

In this manner about one-half of the total CO_2 gas can be returned directly from forecooler to the compressor, the remaining cold liquid can proceed alone to the regular brine cooler, passing the expansion valve and evaporating at the low pressure required. It leaves the brine cooler near its top and then continues to the low pressure suction inlet of the compressor.

The compressor functions as follows: During the downward stroke of pistons the entire cylinder becomes filled with cold low pressure CO_2 gas. Just before reaching the lower end of stroke, the top line of the piston uncovers a number of radially drilled port holes, thus admitting high pressure suction gas which crowds itself in and raises the cylinder pressure to practically the forecooler pressure. The gain in capacity of compressor is proportional to the difference in the density of the low and high pressure suction gas, which is considerable. The efficiency of the evaporator is also increased because of the small volume of cold liquid required.

Mollier Diagram Shows System Characteristics

The difference in performance between the simple compression system and the dual compression system using any refrigerating fluid can be illustrated best by means of a Mollier diagram of a pressure—heat chart such as that produced by the Bureau of Standards and given in Bulletin No. 142. Such charts for both NH_3 and CO_2 were projected on the screen and Mr. Goosmann carefully described every move on the charts. He proved by calculation that, with ammonia, dual evaporation and compression was advantageous only with a high and a low temperature refrigerator while with CO_2 a material gain is obtained with a refrigerator of but one temperature. It was shown that with a liquefaction or condenser temperature of 95 deg. instead of 86 deg. F. only 10 per cent more weight of CO_2 need be handled per minute per ton of refrigeration, with an increase of 15 per cent in compressor horsepower.

The foregoing theoretical discussion was supplemented by slides of tests made with the CO_2 plant in the General Motors Building, Detroit. In this case two 40-t. horizontal double acting machines with 5 per cent clearance volume were used. All water, brine and steam was carefully measured. One test each with slightly wet gas, dry saturated, and slightly superheated gas was run, the last giving the best results in agreement with theory.

As a logical conclusion to his instructive lecture Mr. Goosmann illustrated also the design of CO_2 machines all the way from Windhausen's German machine before 1880 up to date. Up to about 1900 glycerine was employed as a lubricant, but then lubricating oils acceptable for ammonia compressors were found to be equally suitable for CO_2 compressors.

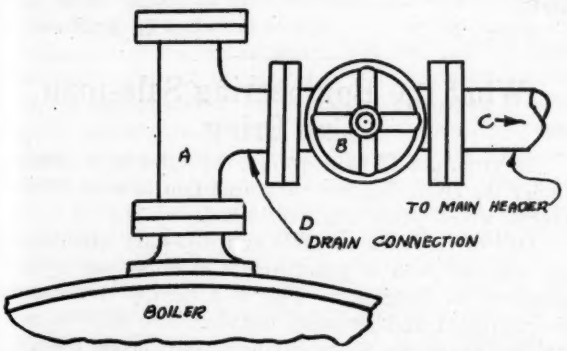
Since condenser water temperatures in Europe are about 15 deg. F. below those prevailing in the United States, many makers still have the rating of their machines on those favorable temperatures. York Mfg. Co. accepts for CO_2 the same temperature levels as for NH_3 and its guarantees are therefore necessarily higher in horsepower per ton.

The present designs of the York CO_2 machine include vertical, single-acting, single or twin cylinder compressors of the enclosed crank case type as well as horizontal double acting machines. Normal rated capacity is based on 5 deg. evaporating and 86 deg. liquefying temperature. The clearance volume is small. A safety valve at the discharge valve cage guards against overpressure. The compressor valves are of the poppet type. Positive oil feed lubrication is used.

Careful Boiler Inspection Necessary After Cleaning

NOT LONG AGO an engineer opened the blowoff valve on a steam boiler and could not get it closed. The fire had to be drawn immediately while the boiler emptied. The blowoff line had only one valve and a globe valve at that. When the bonnet was removed, the trouble was found.

Some time before, the fireman, who was also boiler cleaner, had protested because he thought someone had



SINCE THE BOILER CONNECTIONS TO THE MAIN HEADER WERE LIKE THIS, A DRAIN WAS PROVIDED TO PREVENT LEAKAGE THROUGH VALVE B FROM ENTERING THE BOILER WHEN CLEANING

stolen his pipe. This same pipe was found lodged in the blowoff valve. This is another example of carelessness in boiler inspection after cleaning and should serve as a lesson to those responsible for boiler operation and maintenance. Always be sure that nothing is left in a boiler that may get into a blowoff pipe to cause trouble.

If this blowoff valve had been of proper design, or there had been two valves, the pipe would have gone through in the first case, or lodged in one of the valves in the second. In either case the boiler could have been kept in service until after working hours.

In another plant, carelessness on the part of the cleaner might have caused serious damage and the loss of money. In the accompanying figure, B is the main steam valve and A is connected to the boiler. Since B leaked a little and C was connected to the main steam header, there was a steady drip of condensate through B into an empty boiler being cleaned, incidentally dripping upon the man inside.

In an attempt to hold back this condensate for a short time while he was working under the outlet, the cleaner plugged the outlet opening into A with cotton waste. No harm would have been done if the plug had been removed before the manhole was closed.

Boiler cleaning, however, is a hot, dirty job and usually the cleaners get out at the earliest possible moment and the waste plug is liable to be forgotten. I have heard about such cases several times. One engineer, who had such an incident occur in his plant, first had valve B made steam-tight and then had a hole drilled and threaded at D for a ½-in. nipple and valve which could be kept open at cleaning time in case the main valve should develop another leak in the future.

Many main valves on steam boilers are not absolutely steam-tight because the face of the valve is not perfectly smooth, which means that even a new disc will not make a tight job. My experience has been that the majority of small plants do not have the necessary equipment for refacing large valves in place.

Toronto, Canada. J. E. NOBLE.

Engineering Is Not a Stepping Stone to Something Higher

YOUR EDITORIAL in the July 1 issue, p. 768, under the above title, discussing the relative merits of engineering and finance, has been the subject of much interesting discussion. I cannot agree that an engineer always should remain an engineer. When is an engineer successful? Upon what standards do we judge the merits of any enterprise, be it in the sciences or arts?

With few exceptions, engineering advances have been the result of economic pressure and success or failure is judged by financial standards. It is reasonable to expect that financial engineering will continue to assume increased importance as the engineer comes to a full realization or admission that design is subservient to economics.

Fundamentally, the problem is one of investment, a business proposition requiring engineering knowledge and data for the purpose of determining the most desirable employment of capital.

This may require a determination of the most desirable method of supplying a given service, the choice between two designs, added increment of investment allowable for increased efficiency, or a decision between services to result in the greatest net profit. In industrial enterprises, where capital may be limited, the proper employment of money is especially important. A proposed power plant, although an excellent investment from an engineering standpoint, might be undesirable because the same amount of money invested in another department would give a greater return.

As the engineer's responsibilities are increased, technical details are overshadowed by larger problems of the enterprise and co-operation of various departments. Almost unconsciously the engineering and executive duties merge. By his thorough training in analysis,

clear thinking and experience, the engineer should be eligible to assume responsibilities of the executive.

In spite of vehement denial, engineering is not and never will be anything but a foundation of industry. With exceptions that can be counted on the fingers of one hand, engineers as engineers have not been successful when measured by our present standards, and engineering must be considered as but a stepping stone to higher aims.

Chicago, Ill. MORRIS RICHARD.

How to Advertise Yourself

PROSPECTS FOUND by advertising in trade papers have potential value because an employer who answers an advertisement is in need of a man. Many employers fill their vacancies in this manner because the man who advertises shows initiative.

Efficiency of advertising is in proportion to the care exercised in selecting the medium and in writing the copy. The writer would first select trade magazines, with the large city newspapers as second consideration. The trade papers will reach a greater number of live prospects for the money expended than a direct mail campaign. Do not use the shotgun method in writing advertising copy. We have often read advertisements of this sort, where the principal idea seemed to be, "I can do anything." When a person says he can handle any problem in engineering, the reader of the advertisement probably will question the statement but, by making definite statements of qualifications, you help the employer to visualize you. You must have in mind a definite position for which the advertisement is intended. The employer who wants a combustion engineer is not going to choose him from a jack-of-all-trades advertisement.

Often we read advertisements wherein the statement is made that the salary is of no importance. Such a statement indicates poor business qualities. The employer knows he is not going to get something for nothing and, as you judge your value to him as of no great importance, why should he hire such a man? This style of copy usually conveys the idea that all the prospect is looking for is opportunity, which is quite a waste of space, as it ruins the remainder of the copy.

Your advertising copy should tell specifically what you have done, what you can do and what you want to do. It must create interest, confidence and give sufficient information to enable the employer to judge your ability. It must present his idea of the man wanted for the position. Don't try to be clever. The dignified, business-like copy will appeal to the greatest number of employers. Before sending the copy in to your publisher, request some business man to read it and tell you whether it would interest him and ask for criticism. Usually the motive for hiring a man is the money he can make for his employer.

Running an advertisement once will not bring the results in proportion as the amount spent for three insertions. Repetition is an important part of advertising. Many employers will not hire men who do not show aggressiveness, such as is indicated by several insertions of advertising or calling back several times when applying in peron.

When answering advertisements, analyze carefully the requirements of the position offered and check your qualifications that fill these requirements. Concentrate on the things you know are wanted and leave out the general statements. Such a statement as "I can reduce cost of power production" is a general statement, but "I have reduced the cost of power 20 per cent in my present position" is a definite statement of fact.

Avoid such remarks as "I read your advertisement and thought I would write," "Of course I know you are very busy and I will not take up any more of your time than necessary," "I want to secure a position with your company and I can do any kind of work around a power house," "I have worked here for some time but do not see any opportunity for advancement as the boss does not like me." There are many applications like these and the applicants wonder why they do not receive answers to their letters. These men writing such abominable letters may be first-class men too, but they do not know how to sell themselves.

Put facts in the letter of application. One neatly typewritten page giving a statement of facts is worth a dozen pages of generalities. Answer every question asked.

Fargo, N. D. L. A. HOOD.

What the Engineering Salesman Can Bring

IN THE June 15 issue, p. 713, the letter by B. Marker under the above heading calls attention to some obvious truths which often are overlooked.

One of the most valuable and necessary qualities of an engineer who is practicing his profession is independence of judgment. This is a faculty which must be cultivated and jealously guarded, and any one who has had experience in specifying or purchasing mechanical equipment knows how difficult it is to form an unbiased opinion as to the relative merits of the numerous makes and types which are presented for his consideration.

Unfortunately an unbiased opinion as to the relative merits of his own and competitive equipment is an attribute which the so-called sales engineer cannot afford to cultivate too earnestly. His particular job is to impress his prospect with the desirability of his own equipment and the less he says and thinks about the merits of that of his competitors the better.

It is, perhaps, unfortunate that the term, "sales engineer," has come into such general use, as it implies that the one using this title is competent to play a dual role, the requirements of which are often antagonistic.

The salesman who has a sound technical knowledge of his products is a valuable man but his business is to act as a merchant rather than as a professional engineer and this fact always should be kept in mind.

Unfortunately many people are unwilling to pay for independent engineering service and they hope to get unbiased technical advice from the salesman. This is decidedly unfair to the salesman, and the temptation to give advice which is not entirely without bias is great. His particular business is to advise the use of his apparatus if it appears to be reasonably suitable, so that the prospective purchaser has only himself to blame if he is misled by this. Even among salesmen who have received engineering educations, there are few who, hav-

ing spent a number of years concentrating upon the merits of some particular make of equipment, will retain the ability to form unbiased technical opinions since their experience naturally leads them away from this.

This is all right as far as the salesman is concerned since most competent engineers would prefer to deal with men who confine their attention to describing the merits of their own specialties, and allow their customers to judge between the value of their claims and those of their competitors.

By this means the experienced engineer can obtain valuable information from salesmen, and add greatly to his own professional knowledge. A man of good judgment often can learn more from a salesman who is using his engineering knowledge to substantiate more or less unreliable claims than he can from some one who is trying to tell him the exact scientific truth. This, however, applies only to one who is competent to form an independent opinion upon engineering matters.

Anyone who is not so qualified will likely be misled and he will have no one to blame but himself or those who, from reasons of false economy, fail to provide him with competent technical advice.

Most salesmen of the better sort will not sell their equipment when it is clear that it is unsuited for the purpose contemplated, but with this limitation a salesman is entirely justified in pushing his own equipment without considering that that of his competitor may have greater suitability. It should be kept in mind, therefore, that a sales engineer is a salesman first and an engineer second and it is his business to use any engineering knowledge which he may have, in any legitimate way, to make sales, and he should not be called upon to give free consulting service to those unwilling to pay for it.

Newark, N. J. J. O. G. GIBBONS.

APROPOS of your editorial in the April 1 issue, page 450, under the above title, I wish to add that my own experience has shown that when a salesman representing a responsible concern visits you—you should use him if you can. He will prove himself valuable to you.

He may not be the same capable engineering expert you are, but if he sells oils, for instance, the chances are a thousand to one that he knows more about oils than you do, and if you will give him an opportunity he will save much money for you.

One engineer, for example, states that he is now "handing over the supervision of various details of the plant to the same number of expert salesmen." In that way he has more time to devote to managing the plant. The oil salesman has cut his lubricating costs in half. Furnace repair costs have been reduced 15 per cent. Packing costs have been cut 30 per cent; and so have belting and other costs.

Most salesmen are substantial, solid, practical men, who know their specialty from the ground up. Before they are allowed to go out and sell for a reputable concern they are thoroughly schooled. They must know their competitors' products as well as their own. They must understand the application of their product to all industries. A purely theoretical salesman cannot get anywhere; he must be "practical." Most of the salesmen of today have been mechanics, engineers, or men with a good solid technical backing.

Therefore, when these salesmen happen along, it usually pays to give them a hearing. If you are already doing the best that can be done, a high-grade salesman representing a high-grade house will not pester you but will be on his way; however, it is always well to bear in mind that there are very few conditions that cannot be improved. Opportunities for saving and making money always exist.

Newark, N. J. W. F. SCHAPHORST.

Too Many Engineers Unfit for Job

THERE ARE too many men in power plant practice who ought to be doing other work. At the plant I have in mind the engineer was a man who never should have entered the business of power plant engineering. He did not appear to realize how much depends upon seemingly small details, as for example, that the draft could be greatly reduced by leaks in the brick setting. He was having a lot of trouble in holding up the steam pressure and he asked me to help him out by suggesting some things he could do to improve the service.

Although the boilers were operated with forced draft, according to his directions, the furnace bridge walls had been built curved about 8 in. below the boilers. Due to these restricted openings, since he used heavy fires, the pressure within the furnace was so great that ash and smoke were blown out of the cracks around the furnace doors and elsewhere.

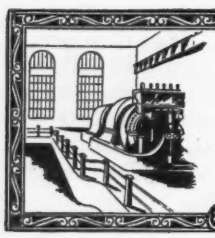
He told me that leaks had shown several times at the girth seams over the fires but he had calked them up tight when the boilers were shut down for cleaning. He had many other troubles, the worst in his own estimation being that he could not afford to drop out of the engineering business. I suggested that the first thing to do was to have a properly qualified boiler man examine and properly calk the leaking seams, then remove the curved bridge walls, making them straight and about 12 in. from the boiler shell at the center, next, that he get enough plastic cement to give the brick work a double coating and thus fill up all the cracks and other air holes in the settings.

These simple and inexpensive repairs and alterations were made and two instead of three boilers carried the load with ease using light fires with the fan running just fast enough to keep the fires at an intense heat. No further leaks developed at the seams and the misplaced engineer lost his worried look. Of course, the main trouble had been lack of room for the free passage of the products of combustion and the cooling of the gases.

There are a number of men like my poor friend, holding operating engineers' licenses and who, like him, are sorry for it, because they know they are not and never will be capable power plant men.

It is regrettable that such men seldom read the power plant journals—the very thing that would help them solve most of their troubles. Many a time I have taken an hour or two to show these men the truth of the above and usually convinced them to a more or less extent. If all engineers would do the same when the opportunity occurred, the business we all take pride in, stationary power plant work, would be benefited and the misplaced men helped.

Toronto, Canada. JAMES ELLITHORNE.



QUESTIONS AND ANSWERS

Power Factor Is Expressed as Ratio

WHAT IS meant by the term kv.a. and also by the term "power factor"? T. L. H.

A. The abbreviation "kv.a." means kilovolt amperes; "kilo" is a Greek prefix meaning one thousand, therefore, the term "kv.a." means volts × amperes ÷ 1000. In other words, if you had 1000 volts multiplied by 2 amperes, the result would be 2000 ÷ 1000 = 2 kv.a.

It might be stated that, in most alternating-current systems, the current lags behind the voltage, chiefly on account of the magnetizing current of transformers, induction motors and other devices, such as electric furnaces and electric welders. The magnetizing current is a reactive current lagging 90 deg. behind the voltage; the active current is in phase with the voltage. The actual current is the resultant of the two and may be considered as having two components—the active component and the reactive component.

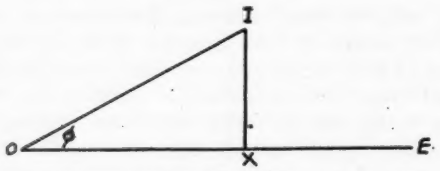


FIG. 1. THIS VECTOR DIAGRAM IS USED IN SOLVING POWER FACTOR PROBLEMS

Referring to Fig. 1, which is a simple vector diagram by which most power factor problems can be solved, OI is the actual current which lags behind the voltage OE by the angle ø. The active component in phase with the voltage is OX and the reactive component 90 deg. out of phase is IX. The power factor of a circuit is the ratio of the active component of the current to the actual current, $\frac{OX}{OI}$ which is the cosine of angle ø.

The ratio of the apparent watts to the true watts, $\frac{kw.}{kv.a.}$, is called the power factor. Watts = volt amperes × power factor. Volt amperes = watts ÷ power factor. Kilowatts = kilovolt amperes × power factor and kilovolt amperes = kilowatts ÷ power factor.

The apparent power in a three-phase circuit is $\sqrt{3}$ EI, which is kv.a. and the actual power is, $\sqrt{3}$ EI cosine ø, which is kv.a. times power factor and equals kw. It is apparent that kv.a. and kw. are one and the same thing at unity p.f. and that for power factors other than unity, the current for a given kw. load changes inversely with the power factor.

In a direct-current system the volts multiplied by the amperes equal the watts transmitted through the circuit. This is true, also, of an alternating-current circuit where the current is in step with the electromotive force, as shown in Fig. 2. Such a condition, however, is rarely true in practice, the current usually being more or less out of step with the volts.

It has been shown that in an alternating-current circuit where inductance is present, the volt meter and ammeter readings give too high a value for the effective volts and amperes. Therefore, the product of these two readings will give too high a value for the useful watts.

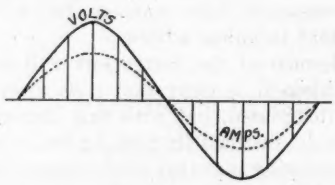


FIG. 2. THESE CURVES SHOW VOLTAGE AND CURRENT IN STEP

For this reason, the product of the volts multiplied by the amperes in an alternating-current circuit is called "apparent watts" or "volt amperes."

A watt meter will read the useful watts or true watts transmitted, irrespective of the relation of the currents and electromotive force.

Deep Well Pump Efficiency Greater Than Air Lift

WHICH IS more efficient, a deep well pump or an air lift? We are now using a duplex pump for a well 6 in. in diameter and 350 ft. deep, pumping at the rate of 150 gal. per min. P. C.

A. Your question regarding the comparative efficiency between a deep well pump and an air lift cannot be answered specifically without more information. The particular type and characteristics of the deep well pump must be known before its efficiency can be determined.

In general, however, if a duplex pump is used, the efficiency of the pump will be from 65 to 70 per cent. If an electric motor is used to run the pump, the overall efficiency will be even higher, as the efficiency of the motor will be from 90 to 95 per cent. If, however, the pump is driven by an engine the overall efficiency will be lowered. The overall efficiency of the air lift itself is subject to considerable variation, depending on the ratio of submergence of the discharge pipe to the lift and also on the amount of air pressure.

By submergence is meant that portion of the whole length of discharge pipe which is submerged. Stated in percentage, the amount of submergence should be

about 60 per cent of the entire discharge pipe, sometimes more, sometimes less.

In figuring the efficiency of an air lift, the overall efficiency must be considered, that is, both the efficiency of the pipe and the efficiency of the air compressor furnishing the air. In general the efficiency of the pipe will be from 65 to 70 per cent, and the overall efficiency from 45 to 55 per cent. It may be seen therefore, that if you use a duplex pump, although you do not state what type of pump this is, the efficiency of the pump probably will be greater than the overall efficiency of the air lift.

To compare any given pump efficiency with that of an air lift, it is necessary to know the size of the well casing, size of the water and air pipes, depth of submergence, height of lift, air pressure used and the indicated horsepower of the air compressor.

Entropy Useful in Heat Calculations

PLEASE TELL me what entropy means or state where a definition may be found? J. H. B.

A. Entropy may be expressed as the ratio of the change in heat in a substance (either with variation of temperature or at constant temperature) to its absolute temperature in the final state.

You will note that this definition is qualified by the clause "either with variation of temperature or at constant temperature" since in the addition or subtraction of sensible heat to a substance the temperature is changing while in the consideration of latent heat a substance may absorb or give off heat without any change in temperature. One example of this may be found in the evaporation of water above the boiling temperature. At atmospheric pressure, at sea-level, approximately 970 B.t.u. must be added to 1 lb. of water to evaporate it after it has reached 212 deg. F. and during this time there is no further change in temperature.

Another way of expressing the ratio of heat quantity to absolute temperature is given by Kent in defining entropy as "the length on a diagram the area of which represents a quantity of heat and the height at any given point represents absolute temperature."

Such a diagram is shown in the accompanying figure. Here entropy may be expressed by the equation:

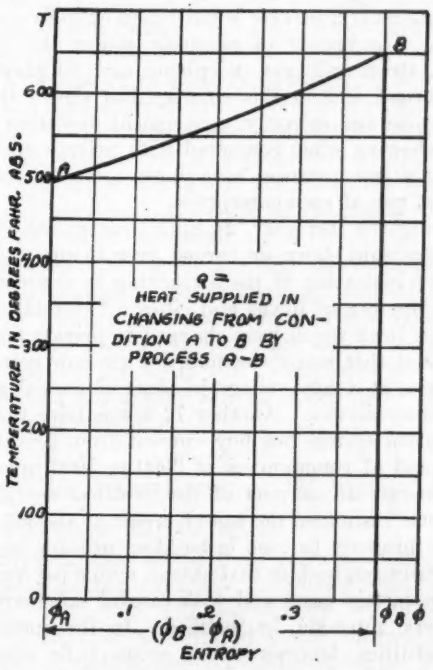
$$(\phi_b - \phi_a) = \frac{Q}{T} \qquad (1)$$

where ϕ_a or ϕ_b is the absolute entropy of the substance in the condition represented by points A and B. $\phi_b - \phi_a$ = change in entropy. T = absolute temperature at which heat is exchanged; Q = quantity of heat in B.t.u., added or subtracted in passing from state A to B. This quantity is represented by the area under the change of state curve, AB, down to zero on the horizontal axis.

Horizontal distances on the temperature-entropy diagram are derived quantities and not directly measurable physical quantities as are volumes and temperatures. These horizontal distances or entropies can be laid off from an absolute zero of entropy or from any given value as a starting point, but as practical problems deal only with cyclic heat changes and not with total heat content, it is customary to plot only entropy differences in passing from one state to another. Thus may be created an artificial or arbitrary zero of entropy at the point where the heat content of the body is least. Entropies measured from this point are really differences in entropy between any point and that point where the body has least heat content. Equation (1), therefore, may be expressed as

$$E = \frac{Q}{T} \qquad (2)$$

In this case E is the change in entropy from A to B, equal to the horizontal distance between the diagram points.



IN THIS DIAGRAM, ENTROPY IS THE HORIZONTAL ORDINATE AND TEMPERATURE THE VERTICAL. THE AREA UNDER THE THERMAL PROCESS CURVE IS THE QUANTITY OF HEAT INVOLVED

If the temperature is constant it is easy to understand what entropy is. For instance, in Marks & Davis steam tables, you will see that for 200 lb. pressure the temperature is equal to 280 deg. F. and that the latent heat of evaporation is about 843 B.t.u. This 843 B.t.u. is added during a constant temperature, the absolute temperature being 382 plus 460 or 842 deg. Using equation 2 you will see that the entropy is equal to the heat change or 843 B.t.u. divided by the absolute temperature of 842 deg., giving an entropy of 1.0019. This, however, is the only case in which entropy can be figured in such a simple manner.

For conditions where both the temperature and heat content are changing simultaneously as in the heating of a liquid to the boiling point or the superheating of a vapor, entropy may be expressed by the equation:

$$E = C \times \log_e \frac{T_1}{T_2}$$

where C = mean specific heat between T_1 and T_2, T_1 = absolute temperature in the first state, T_2 = absolute temperature in the final state.

EDITORIAL COMMENT

Municipal Ownership

Thoughtful students of government activity have doubted the advisability of any governmental organization doing what a private organization or individual can do well. The history of railroads, power and lighting systems, street railways, telephone and telegraph systems, abroad and in this country has shown that, in effectiveness and economy, government operation makes a poor showing when compared with private operation, although a few instances have shown better success than the usual run of such enterprises.

During the last year, 28 municipal plants in Iowa have been shut down or turned over to private enterprise, an indication of the awakening to common sense of that number of towns and cities. The total of such plants in Iowa which have changed to private operation is 107 and that many communities are now getting 24-hr. service at steady voltage in place of partial and unsatisfactory service. Another 72 towns have their own distribution system but buy current from private companies and 57 communities of 2000 to 5000 inhabitants still generate all or part of the electrical energy used.

In some instances, the use of credit of the municipality may properly be used in building utilities, especially street railways, and, to that extent, municipal ownership may, in certain cases and with careful safeguarding of taxpayers' interests, be justified. In the operation of those utilities, however, there seems little chance, as shown by the records of municipal operation, that governmental management can make a showing at all comparable with that of private management. In every case where fair and impartial comparison of results has been made, private operation has proved more efficient. It seems difficult to justify from facts municipal ownership except as a last resort to secure needed and desired utilities which private capital will not provide; and municipal operation, never.

Interchange of Power Offers Economic Possibilities

Notable work has been done by committees of the National Electric Light Association in making surveys of various industries which offer a market for power. Little has been done, however, toward investigating the possibilities of purchasing power from those industries which have found it profitable to own and operate their own power plants. Many of these industrial plants operate at a high load factor all day long and drop nearly to the zero point at the evening closing time when the lighting and electric railway loads on the central stations are mounting to peak conditions. To supply this peak demand for power, many central stations must provide surplus power equipment which cuts their average load factor down to 40 per cent or less, necessitating an excessive initial investment with accompanying interest charges.

True economy in the development and use of power would suggest an interchange of power between large industrial plants and central stations, whereby the entire electric load of the community would be so distributed among all the generating plants as to give the highest possible load factor on the most economical plants, with the less economical plants taking the swing of the load.

Such complete co-ordination and co-operation can hardly be expected but, if the possibilities were thoroughly investigated, we have no doubt that a vast amount of capital now being invested in generating equipment for both industrial plants and central stations could be used for other purposes and that the average cost of generating power would be reduced.

With his characteristic genius for economy, Samuel Insull, in the following paragraphs taken from his address at the recent convention of the N. E. L. A., indicates that this problem is one for the electric utilities to investigate and solve.

"Another detail that might well repay thorough examination, and one that may contain economic advantages far beyond anything now realized, is the possibility of interchanging power with large industrial institutions which have considerable electrical generating capacity and of which the basic steel mills are an example.

"The large steel companies have not yet freely admitted that they can advantageously interchange energy with local utilities. Perhaps pride of position has been a deterrent. Until recently the steel companies in many instances have been financially larger enterprises than the utilities. If this has been a deterrent, the consolidation of electrical enterprises, as an economic consequence of interconnection, should tend to correct it.

"Anyhow, the electrical industry need not wait for the other side to realize the situation and the opportunity. It is up to electrical men to make the first move and educate the others to the economic possibilities of the situation."

In the interest of economy to the community, engineers in industrial plants will do well to co-operate with the central stations in any effort they may make to work out an arrangement for interchange of power.

Eliminating the Middleman in Engineering

Regardless of what has been written or may be written in the future concerning the position of the engineer in relation to our social, economic and political organization, there is still a widespread feeling in the engineering profession that none of it does him any good and probably never will do him any good. We were

considerably interested, therefore, at a recent large gathering of engineers to hear an opinion expressed on this subject that seemed to us to go to the root of the matter. One of the speakers, a prominent engineer himself, remarked that the engineer necessarily works under a handicap because, unlike the lawyer, the physician, the clergyman, and other professional people, he does not come into direct contact with the people to whom he renders his services.

This statement had apparently the same effect on the audience that Columbus's famous egg trick must have produced. Once the statement is made, its truth is so obvious that the hearer wonders why he didn't think of it himself. The engineer, by virtue of the fact that he must be a specialist in order to be an engineer, must always work through the medium of what our friends, the economists, call an "entrepreneur"; that is, an enterpriser, a man who undertakes things, a non-technical executive, in other words.

To help in remedying this situation, the speaker, referred to above, suggested that the engineer might do two things: first, he might create a stronger impression on the general public by praising at every opportunity the work of his fellow engineers, whether in his own line or not; second, he might interest himself in some type of public service where his engineering training would be effective but in which little or no remuneration would be involved. He might thus obtain a direct contact with the public he serves. The speaker pointed out also that he was not at all sure that an engineer should endeavor to engage in public affairs unless he is financially independent so that he can afford to do so because, from the ethical standpoint, it is just as necessary for him to insure his own financial independence as it is for him to attempt to serve the public.

With both of these ideas, we are in hearty agreement. The method of putting them into practice will necessarily depend upon the particular conditions under which the individual engineer must live and work. The man who advanced these ideas has proved their worth by applying them in practice for many years. A little more boosting of our fellow engineer to the general public and a little more interest in those public activities in which the specialized training of the engineer can be made effective will do much to remove the handicap under which the engineer must do his work, a handicap caused by the fact that the results of his work must be transmitted through an intermediary to the public he serves.

Standardization and Simplification

Because it is the natural tendency of engineers to try out various ways of doing things, then adopt the one or the few which prove best and because of the necessity for interchangeability in making renewals and extensions, power equipment and apparatus has always tended to become standardized and simplified.

Piping, bolts, lamp bases, gears, of other than standard sizes are almost unthinkable. And the standards are the result of much thought and experiment to adapt them for their purposes.

True, with the rapid changes in steam pressures and voltages new developments are constantly shaping but each step forward is resolved into standard practice with surprising promptness. Never has there been an effort to multiply types and sizes of machines but in some cases simplification has been found possible as the result of experience, a notable instance being the new series of incandescent lamps which are coming rapidly into universal use. Another instance is the recent reduction in number of pipe sizes from 64 to 42 and of number of sizes of valves and fittings from 20,000 to 19,238.

Work of the Division of Simplified Practice of the Department of Commerce has resulted in great savings to industry, running to such amounts as $1,000,000 a year in paving brick and $200,000,000 a year in lumber and in percentages of varieties as high as 90 per cent, without impairing the usefulness of the product.

No such reductions as these are possible in power plant equipment because of the before-mentioned natural standardizing as the industry has developed but in each plant it is possible to simplify operation by keeping the types and sizes of equipment as few as is consistent with economy. It is worth while, occasionally, to go over a plant and consider just why each piece of apparatus is used. Whether it was wisely chosen in the first place, whether it still meets the needs of the plant, whether it fits in with other equipment.

Periodic housecleaning is a desirable operation to get rid of antiquated or outgrown ideas, methods and belongings. And when housecleaning it is always wise to keep in mind that working to standards of convenience, usefulness and simplicity will reduce labor and expense of operation and upkeep as well as increasing efficiency, comfort and reliability.

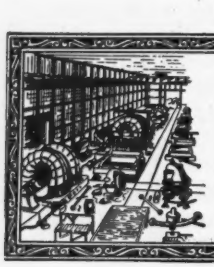
Scientific Investigation Menaced by Private Enterprise

During the past two or three years great strides have been taken in the coordination of pure science and engineering. As usual with investments which show no direct return, the majority of manufacturers are loud in praise of results accomplished but vanish when the hat is passed for a collection.

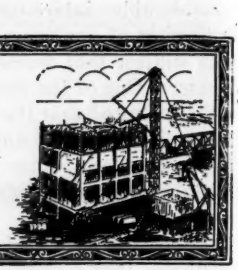
Either as an advertising feature, or a genuine effort to improve their product, many of these same manufacturers have gone into the field of science and taken the leaders of worth and reputation into their own organizations. Regardless of the purpose back of such a move, its continued practice can result only in the gradual breaking down of scientific investigations by eliminating the more proficient investigators and causing dissatisfaction among those who do not secure commercial connections.

With the exception of a few larger companies, a research organization must pay for itself, hence the field of science is domineered by commercial requirements. Even the investigations carried on by those organizations who can allow the scientist free reign, are of little value to the general public because of the strict censorship maintained.

To be of maximum value to the public, scientific research must be conducted by public bureaus and must be free of commercial alliances. This can be accomplished only by recognizing that, in spite of an inborn curiosity as to discovering new things, even a scientist must live and that he deserves a remuneration somewhat in line with his commercial value to a private organization. Proper financial support is necessary to build up and maintain the scientific departments of the government against the inroads of private competition.



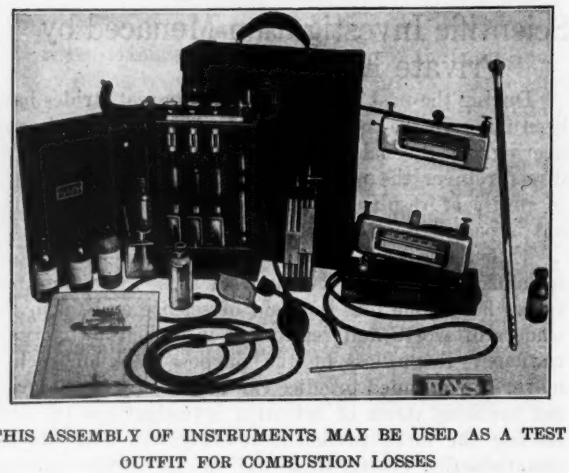
POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Hays Develops New Portable Test Set

ESPECIALLY designed for service men, combustion engineers and others interested in the quick determination of combustion losses and the location of trouble, a testing outfit has just been placed upon the market by the Hays Corporation of Michigan City, Ind. As shown in the accompanying figure this assembly consists of a portable flue gas analyzer, steel armored flue gas thermometer and a draft gage, all compactly arranged in a light, but strong case, convenient for use.

The gas analyzer is the standard, well-known Hays gas analyzer for determining CO_2 and also if desired CO and O_2. The draft gage is of the adjustable inclined tube type and measures 9 in. in length and 4 in. in height. The range is ½ in. of water, either draft or



THIS ASSEMBLY OF INSTRUMENTS MAY BE USED AS A TEST OUTFIT FOR COMBUSTION LOSSES

pressure, graduated in hundredths, or the Hays Vernier type draft gage may be used for higher ranges. This portable test set is suitable for power plant operators, combustion engineers, and all others engaged in checking combustion losses.

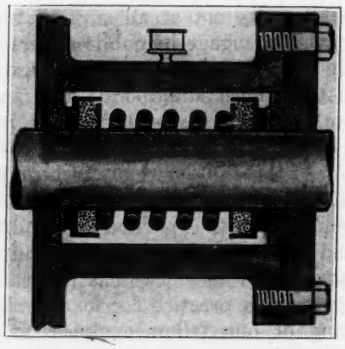
Both the gage and the analyzer are provided with leather cases so that either may be carried separately. Both, however, can be placed in the large carrying case, shown in the center, for immediate transport from one location to another. This case measures only 4 by 14 by 18 in. It can be slipped into an automobile or underneath the seat of a train. The combined weight is less than 20 lb.

With this testing kit it is possible to make a complete check on the efficiency of combustion so that service men are quickly able to adjust combustion control devices.

In the illustration is shown the complete outfit with the accessories and extra parts which are furnished. Two of the inclined type draft gages are shown in order to illustrate how the gage may be mounted to a wall with the knurled screw which is furnished or placed on a flat surface and leveled with the micrometer screw on the detachable supporting foot.

New Seal Ring Can Be Adapted to Any Rotating Shaft

TROUBLES with packing on shafts of rotating machinery, such as centrifugal or rotary pumps handling ammonia, carbon dioxide, sulphur dioxide, brine,



SEAL RING ASSEMBLY SLIPS OVER END OF SHAFT

gasoline and other liquids are a constant source of annoyance to the operator besides lowering the pump efficiency. A packing for such shafts, known as the Cooke Seal Ring Assembly, has recently been placed on the market. This packing is designed to prevent all leakage of liquid or gas through the packing glands. The entire assembly, shown in the accompanying illustration, is slipped on over the end of the shaft and rotates with it.

This packing consists essentially of a patented metal specially heat treated seal ring with a housing in which is fitted a rubber ring or any soft packing such as wicking, pressure being applied by a spring that exerts a force of about 20 lb. when compressed, frictionally binding it to the shaft and rotating it with the shaft against the inside face of the stuffing box gland. If the gland is of brass or soft metal it must be bushed with cast iron or semi-steel. The inner end of the spring bears against a second rubber ring or other packing in housing, which in turn bears on a second seal ring at the bottom face of the stuffing box.

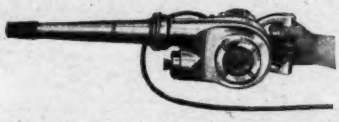
Between gland and stuffing box a gas tight gasket about 1/16 in. thick is used. The stuffing box now becomes an oil reservoir, so that the ground joint made by the seal rings will be lubricated, since the part of the ring will run submerged. This oil can be supplied by an oil cup or grease cup, as shown. If the stuffing box receives oil from splash in a crank case, a lantern ring is used at the bottom of the stuffing box. In case a shoulder is available on the shaft inside the stuffing box, the inside ring can be omitted and the spring can bear on an ordinary steel ring pressed against this shoulder.

The Cooke Seal Ring was developed by George J. Cooke of the Cooke Cold Storage Co., Chicago, Ill., during the process of developing a small household refrigerating machine of the ammonia compression type. The compressor of this machine has its crankshaft projecting through the crankcase to carry the driving pulley on its outer end. Since the crankcase must be gas tight and since the machine has only 3½ oz. of ammonia charge, the shaft had to be tight to prevent ammonia leaks and the seal ring was designed to perform this function. Since its installation on these refrigerating machines, no ammonia leaks have occurred and it has run for five years with no trouble, leaks or attention.

In the larger sizes it has been installed on many centrifugal pumps handling brine, water, chemicals, gasoline and so on. Such installations made over a year ago, are operating with no leakage whatever. The assembly, once it is installed, has no adjustments and is designed to run with no other attention than that of supplying lubrication on the double seal type. Tests have shown that the friction loss caused by this packing is extremely low on account of the small and well-lubricated bearing surface of the seal rings.

Ball Bearing Cadillac Hot and Cold-Air Blower

FOR EVAPORATING condensed moisture, a blower known as the Ball-Bearing Cadillac Convertible Hot and Cold-Air Blower has recently been placed on the market. This unit is designed particularly for use in public service companies, and all power plants where condensed moisture in motors and cables is a menace.



THIS BLOWER, WEIGHING 9 LB., SUPPLIES HOT OR COLD AIR

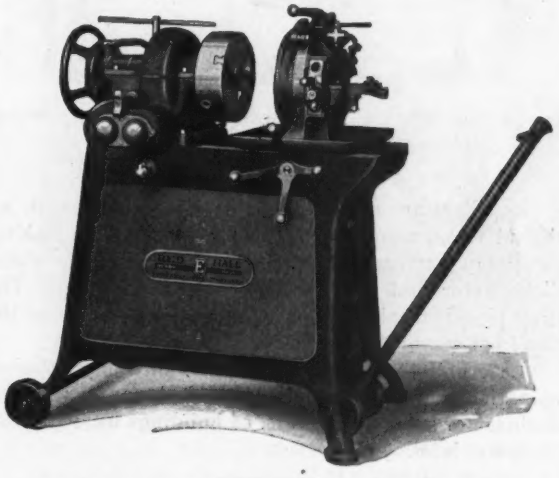
Since it delivers 47 cu. ft. of air a minute at a temperature of 135—140 deg. F. and with a velocity of 13,470 ft. a minute, quick and thorough drying of cables, wires, motors, switchboards and terminal boards may be obtained with it.

Although the blower weighs only 9 lb., it is complete in itself, requires no expensive installation or equipment and operates from any electric light socket; it is equipped with a full 1/3-hp. motor and Norma ball bearings and is designed to stand up under the hardest kind of service. With the heating element turned off, it can be used as a cold-air blower to blow dust and dirt out of motors, machinery, line-shafting and other equipment. It is manufactured by the Clements Mfg. Co., Chicago, Ill.

New Portable Electric Pipe Machine

OFTEN, keeping the tool on the job at the point where it will be most effective results in considerable savings. The new Red-E.-Hall portable pipe cutting and threading machine is designed to follow the erecting job but can be quickly changed to a stationary machine for production work. Rear feet are mounted on wheels and the front end has swiveled castors with handle which elevates the front end as it is moved forward and sets the forward feet on the floor when the handle is released. Castors, wheels and truck are easily removed when the machine is to be used in one location.

Capacity is from ¼-in. to 2-in. pipe and ½-in. to 1½-in. bolts, with a 1-hp. motor for driving mounted



PORTABLE PIPE MACHINE FOR ¼ TO 2-IN. PIPE

below the bed of the machine and controlled by push button or snap switch for start, stop and reverse. Silent-chain drive with friction clutch for start and stop give convenient and positive control, with three spindle speeds available by the selective slide system of gears.

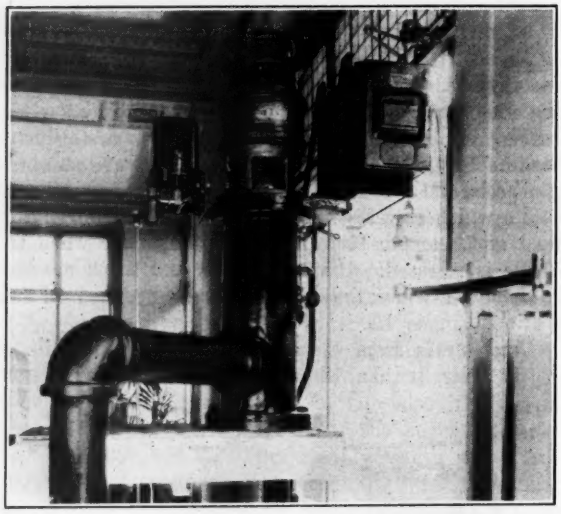
Features which make for convenient operation are a locking lever for opening and closing the die head, forced lubrication of cutting dies, adjustment nuts for under and over-size threads, rapid-acting cut-off attachment with reamer and chamfer lever on the cut-off block.

Construction of malleable iron and steel, Timken roller bearings on drive shafts, ability to handle close nipples, chip-pan with drain to the oil reservoir and universal shaft which permits driving hand stocks up to 12-in. for right or left-hand threads are points which make for durability and efficient service.

The machine is made by Hall-Will, Inc., of Erie, Pa.

Axiflo Principle Applied to Sump Pump

BY APPLYING its Axiflo deep well pump principle, the Worthington Pump & Machinery Corp., 115 Broadway, New York, has developed a simple, compact sump pump automatically controlled by means of a float switch and driven by a vertical motor.



AN AXIFLO SUMP PUMP INSTALLATION COMPLETE WITH FLOAT SWITCH AND MOTOR CONTROL BOX

Impellers are of the flat or propeller type with no shroud rings, wearing rings or close clearances, making the pump particularly adapted to sump service where dirty water and sand are likely to be handled. The drop pipe not only supports the impeller section of the shaft but serves as a discharge pipe as well.

Ease of installation, low maintenance and noiseless operation make this pump particularly applicable for drainage of sumps, or cellars, of buildings located below the sewer level.

Laundry Installs Turbo-Generator

LENOX LAUNDRY, Mt. Vernon, N. Y., recently started operations with completely electrified equipment, generating its own electric power. Two 120-kw., 240-v., 3-phase, 60-cycle, geared turbine generators are used, operating non-condensing. The power furnished by these is used for lighting and for driving the motorized laundry machines throughout the plant. The exhaust steam from the turbines is used for heating the building and also in the laundry processes.

In the use of the turbines, the great advantage has been found to be the resulting clean exhaust steam and the economy in floor space. The ability of the turbine to operate at high back pressure insures sufficient exhaust steam to meet heating and process requirements. Complete electrical equipment was furnished by the General Electric Co. The installation was made by Francisco & Jacobus, New York, architects and engineers.

Back-Geared Attachment for G. E. Induction Motors

DESIGNED TO operate under the most unfavorable conditions, a back-geared attachment is announced by the General Electric Co. for use with its "500 series" induction motors. This attachment is of unusually strong construction, is easily installed and easily adjusted. The base, to which the motor and back shaft pedestals are bolted and doweled, is a single, large casting. A special unit-type pedestal is used, one casting forming the housings for the large back shaft bearings. This design assures maximum rigidity and permanent, correct alignment of shafts and meshing of gear and pinion.

The back shaft is provided with shoulders to limit end play and is made of special steel. It is supported by two extra large, double-seated, split bearings in dust-proof housings, holding oil sufficient for a number of months' operation.

A split gear case, fabricated from steel plates, protects the gear and pinion from dust and retains the grease or oil in which the gear runs. Two standard gear ratios are avialable. Steel or fabroil pinions with cast iron gears may be used. Two box-type welded rails with an easy adjusting feature complete the equipment.

Grease Furnished in Collapsible Tubes

FOR THE PURPOSE of simplifying the lubrication of motors Fairbanks, Morse and Co. have recently placed on the market grease in collapsible tubes, each tube containing just enough grease to satisfy the annual

SHOWING APPLICATION OF GREASE TUBES IN LUBRICATING A MOTOR

requirements of their ball bearing motors. After flushing out the old grease with kerosene as directed in printed instructions supplied with the tube, the new FMCO grease is squeezed from the grease tube directly into the bearing. The directions show just how much to put into each bearing for the best result. Four sizes

of tubes are available for corresponding sizes of bearings. The kind of grease best adapted for ball bearings is used. It is of proper adhesiveness to cling to the balls; it maintains its consistency through all normal temperatures without being too stiff when starting in the cold, or melting and flowing out of the bearing when running at full load. It is free from gritty or corrosive constituents. No dirt or other deleterious matter is introduced into the bearing. The likelihood of using a stick or other random object of questionable cleanliness or taking grease from an open can to the bearing is entirely eliminated. The cap of the housing is not removed, only the plug. No grease is wasted or smeared outside of the housing and no wiping is needed.

National Arch Blocks Replaced in Record Time

RECENT tests by the M. A. Hofft Co. have shown the astonishing rapidity which the simplicity of their design permits in replacing a spalled or broken arch block on the National suspended arch.

This is made possible by the method of suspension, as each tile is hung on its own bolt, free from any strain

FIG. 1. PREPARING FOR THE NEW BLOCK BY REMOVING THE OLD ONE

or from the weight of any tile or brick. This makes it less liable to spall or crack under the continued heating and cooling of the furnace than when it is under strain.

Any block may be replaced in 15 min. without disturbing any other block. It does not require the services of a bricklayer; anyone who can handle a hammer and chisel will do just as well.

Fastened to the supporting I-beams, above the arch, are hinged lugs which drop into place and grip each tile bolt, as each tile is inserted. These lugs also prevent side creep of the bolt.

P. G. & E. Co. Builds Hydro Plant as Part of Irrigation Project

BESIDE the Stanislaus River, near the famous old mining town of Melones, the Pacific Gas & Electric Co. is driving a tunnel through a mile of Sierra granite and is starting the erection of a hydro-electric power plant of 35,000-hp. capacity. A mile up the river the Oakdale and South San Joaquin Irrigation Districts are building a dam across the canyon to impound the water from the mountain snows to operate the power plant. The dam is two-thirds done and nearly a half mile of tunnel has been bored. When the project is completed, the irrigation districts will sell their impounded water to the Pacific Gas & Electric Co. and after the water

FIG. 2. THIS NEW BLOCK WAS REPLACED IN 15 MIN.

has spent its force in developing electric power it will be passed into the canals of the two districts to add to the fertility of farms and orchards in the valley below.

Under the co-operative agreement, the irrigation districts voted bonds for $2,200,000 to build the dam and the Pacific Gas & Electric Co. is spending $2,500,000 on the power plant.

Work on the dam and the power plant began last fall and continued through the winter. The dam, a concrete structure of the arched type, is located 30 mi. east of Oakdale in the gorge known as Iron Canyon. When completed it will rise 185 ft. above stream level and have a width of 590 ft. at the crest. The tunnel, which is approximately 13 ft. in diameter, will be lined with concrete. With no attempt at breaking records, it is going ahead 18 ft. a day through the solid rock, a 200-ft. adit enabling the miners to work on two faces. The power house will be completed by May 1, 1927, at which time a new transmission line, which is to be built from the Melones plant to Copperopolis, will be ready to feed the new supply of power into the Pacific Gas & Electric Co.'s great interconnected power system.

Death Takes Charles A. Coffin

CHARLES A. COFFIN, founder and for 30 yr. head of the General Electric Co. as president and chairman of the board of directors, died late Wednesday night, July 14, at his home in Locust Valley, L. I., at the age of 81 yr.

He was born in 1844 in Somerset County, Maine. After graduation from Bloomfield Academy, he built up a successful shoe business, in partnership with M. P. Clough, at Lynn, Mass. In 1883, he assisted in forming a syndicate for the purchase of the American Electric Co., headed by Prof. Elihu Thomson. This company, its name changed to the Thomson-Houston Electric Co., elected Mr. Coffin its vice president and treasurer, and he exerted a dominant influence in the development of the central station idea for arc lighting, in the manufacture of the street railway equipment and in the consolidation in 1892 of the Thomson-Houston Co. and the Edison General Electric Co., the latter of which had acquired all the activities of Thomas A. Edison's incandescent lamp development. After this consolidation, Mr. Coffin was elected president of the new company, known as the General Electric Co., a position he held for 21 yr. In 1913 he retired from the presidency to become chairman of the board, in which position he remained active until 1922.

As a tribute to Mr. Coffin on his retirement in 1922, the General Electric Co. established the Charles A. Coffin Foundation of $400,000 for the purpose of making awards to recognize achievement in the development of light and power and electric railways, to aid research graduates of American colleges and to reward G. E. employees for contributions to the company's efficiency and progress.

During the World War, Mr. Coffin was active in organizing and carrying on the War Relief Clearing House. He was an officer of the Legion of Honor, commander of the Order of Leopold II, and held honorary degrees of Doctor of Laws from Union College, Bowdoin and Princeton, and of Master of Arts from Yale. He was a director in many large industrial enterprises and devoted much time to industrial relations, exchange of educational facilities with France, public and private charities, horticulture and forestry.

Cheat Haven Hydro-Electric Plant Nears Completion

THE WEST PENN POWER CO., Pittsburgh, Pa., is arranging for the early completion of its hydro-electric generating plant at Cheat Haven, Pa., on the Cheat River, in course of construction for a number of months past. Two of the four waterwheel-driven generators, each with a capacity of 18,000 kw., are ready for service, and the other two units are expected to be completed during July. The power dam is 1110 ft. long and 105 ft. high. The station will be the first of a series of such developments now planned by the company on the Cheat River, comprising in all nine power dams and hydro-electric power stations with gross rating of 400,000 kw.

IN THE average department store only 20 per cent of the clerk's time is given over to actual selling.

Reviews Progress of the Detroit Edison Co.

IN CONNECTION with the announcement that Alex Dow, president of The Detroit Edison Co., has just completed the thirtieth year of his service as head of the company, The Detroit Edison Synchroscope gives an interesting review of the progress made under Mr. Dow's leadership during that time.

In 1896, when Mr. Dow began his work as general manager, the company, competing with three other electric lighting companies, operated two power plants 1½ mi. apart, connected by a pair of 500,000-c.m. cables. The main plant was equipped with a number of small generators belted to reciprocating steam engines and totaling about 1000 kw. in capacity. The second plant with similar equipment was good for about 360 kw.

About 2000 customers were served and the entire staff of the Edison Company was made up of 48 men and boys, together with one woman, who was the cashier. The highest paid of the employes was Henry Ford, who, as chief engineer, received $100 a month for his services. Salaries of the other employes, ten of whom are still with the company, ranged from $20.00 to $90.00 per month.

As a contrast to the humble beginnings of the company, it is noted that The Detroit Edison Company now serves 17 cities and 59 villages, covering more than 4000 sq. mi. of territory and including 475,000 customers. At the Trenton Channel station of the company turbo-generators of 50,000 kw. capacity are installed, producing a kw-hr. from 1.2 lb. of coal.

News Notes

NOMINATIONS FOR OFFICERS of the American Society of Mechanical Engineers for 1927 were announced at a recent meeting of the nominating committee held in Chicago. The nominees are:

For president: Chas. M. Schwab, Chairman, Bethlehem Steel Corp. Vice presidents: Chas. L. Newcomb, Manager, Dean Works, Worthington Pump & Machinery Corp.; E. O. Eastwood, Professor, Mechanical Engineering, University of Washington; Edwards R. Fish, Vice President, Heine Boiler Co. Managers: Paul Doty, Chairman of the Board, Minnesota State Board of Registration; Ralph E. Flanders, Manager, Jones & Lamson Machine Co.; Conrad N. Lauer, Treasurer & General Manager, Day & Zimmermann, Inc. Treasurer: Erik Oberg, Editor of Machinery.

THE STATE LEGISLATURE, Oklahoma, has adopted a measure stipulating that the manufacture of ice in the state is a public utility and accordingly comes under the jurisdiction of the corporation commissioner. Like legislation for artificial ice is also being considered by the states of Kansas, Louisiana and Texas, at the present time.

AT A JUNE COMMENCEMENT marking the completion of studies in the technical schools of the company, 282 employes of the New York Edison Co., New York, and its affiliated utilities received certificates; 25 of the graduates were accorded special awards for completing the course of instruction with ratings of 98.5 to 99.9. In

laboratory practice alone, the company has been conducting five courses of instruction, and a comprehensive course of study in the accounting division. Frank C. Stockwell, professor of electrical engineering, Stevens Institute, Hoboken, N. J., is associate educational director of the company, and presented the certificates to the graduates.

NINE YEARS will henceforth be the minimum time in which a degree of engineer may be won from Lehigh University, according to an official statement by President Chas. R. Richards. After the usual 4-yr. undergraduate course, a candidate for the degree of engineer must complete five years of responsible practical experience and must submit a suitable thesis. In connection with this change the undergraduate courses will be revised to place greater emphasis on the fundamentals of engineering and less on the specialized details of engineering practice. Non-technical subjects will also be given more prominence.

THE ROCHESTER ICE & COLD STORAGE UTILITIES, INC., Rochester, N. Y., has been organized to consolidate six local companies, the Harper Co., Rochester Refrigerating Co., Rochester Cold Storage & Ice Co., Silver Lake Ice Co., Flower City Cold Storage & Ice Co. and the Kondolf Brothers Cold Storage & Ice Co. The combined plants have a present gross capacity of 120,000 t. of artificial ice and 30,000 t. of natural ice a year. Frank L. Conrad and George H. Matthews, both of Chicago, will be president and vice president, respectively, of the new company.

ARTHUR W. THOMPSON, Pittsburgh, Pa., heretofore president of the Philadelphia Co., operating the light and power utilities in the Pittsburgh district, has been elected president of the United Gas Improvement Co., Philadelphia, Pa., also a large operator of light and power properties in different parts of the country, effective Sept. 1. He will succeed Samuel T. Bodine, who becomes chairman of the board of directors, a recently created office.

ARTICLES OF INCORPORATION of the Pacific States Cast Iron Pipe Co., organized under the laws of Nevada, have been recently filed at Salt Lake City, Utah. Preliminary work has been done toward the construction of a pipe manufacturing plant near Ironton to manufacture all kinds of cast iron pipe from pig iron furnished by the Columbia Steel Corp.

THE TRIUMPH ELECTRIC CORP. has been organized to take over the good will, designs, records, patent rights and inventions of The Triumph Electric Co., Cincinnati, O. As far as practicable, the new company will retain the former personnel and promises its customers prompt service on existing installations.

AMERICAN PULVERIZER CO., St. Louis, Mo., has appointed A. M. Lockett & Co., New Orleans, La., to represent it in Louisiana and southern Mississippi. It also appointed Titzel Engineering & Equipment Co., Pittsburgh, Pa., as its representative in western Pennsylvania, western Virginia and West Virginia.

SIX NEW ELECTRIC monorail hoists, ranging in capacities from 3 to 12 t., are announced by the American Engineering Co., of Philadelphia, as additions to its line of LO-HED hoists. Each of the new hoists is made in types for bolt suspension, hand-geared trolley, motor trolley and cab control. Open cabs are provided for indoor use and closed cabs for outdoor service. The hoists can also be supplied with push-button control or remote control. Foundry-type control is provided when desired.

These hoists embody the same principles of design that characterize the other models of LO-HED hoists, with such additional features as are made necessary by the higher speeds at which they operate and the heavier loads they are designed to handle. Rated capacities are 3, 5, 6, 8, 10 and 12 t., so that the complete line now includes hoists from ½-t. to 12-t. capacity.

DEAN HILL PUMP CO. announces the opening of its Philadelphia office, 816 Real Estate Bldg., with R. W. Nagle as manager.

SERGIUS P. GRACE, New York, has been elected president of the New York Electrical Society during the ensuing year. J. P. Alexander of the General Electric Co. has been elected a vice president.

THE L. J. WING MFG. CO. has purchased the factory at Newark, N. J., which it has occupied for the last 5 yr., and will erect an extension to the present building, increasing capacity 50 per cent.

GEORGE J. HAGAN CO. has appointed the following representatives: The Jampol Co., 30 Church St., New York, N. Y.; H. E. Haslett, 2192 Railway Exchange Bldg., St. Louis, Mo.; R. L. Sheraton, 12 Pearl St., Boston, Mass.; John H. Bricker, 816 Otis Bldg., Philadelphia, Pa.

OWING TO THE INCREASE in volume of the business of Yeomans Brothers Co., Chicago, Ill., manufacturers of pumping machinery and sewage ejectors, an addition will soon be made to its factory, enlarging it by 20 per cent. A complete new testing plant with a capacity of approximately 200 hp. will be installed.

L. F. KUHMAN has been appointed vice-president and director of the Andrews-Bradshaw Co., Pittsburgh, Penna. Mr. Kuhman has been associated with the company for the past three and a half years. For eight years prior to that time he was engaged as sales engineer for the Ingersoll-Rand Co. in the Pittsburgh district.

JAMES G. O'KEEFFE, formerly engineer of construction, gas department, Public Service Electric & Gas Co., Newark, N. J., has been appointed general superintendent of manufacture in the gas division, effective July 1. Frederick A. Lydecker, assistant general superintendent of distribution of the gas department, has become general superintendent of distribution, beginning July 1.

WHAT ARE STATED to be the lowest quantity rates for electric service now prevailing in any part of the country have been placed in effect by the municipal gas and electric department, Holyoke, Mass., July 1. Charges, arranged on a sliding scale, start at 6 cents per kilowatt-hour for the first 100 kw-hr. during the month, reducing to 3½ cents where service reaches 1000 kw-hr. or more during a calendar month.

R. M. GRINDLEY, owner of the Convention Hall Building, Detroit, Mich., is rearranging the Woodward Avenue frontage of the building for use as a manufacturer's permanent exhibit and sales bureau. Departments for equipment in various sports, in hotels, apartment houses and clubs, in building construction and in various De-

troit manufacturing plants will be established. Manufacturers may secure desk room for their representatives and arrangements will be made for organization of sales forces and reports of business prospects and development. The sales force will be under the direct supervision of W. R. Anderson. The main office of the bureau will be at 4611 Woodward Ave., Detroit.

JOSEPH K. BUCHANAN, vice president and general manager of the West Virginia Utilities Co., Morgantown, W. Va., and the Wheeling Public Service Co., Wheeling, W. Va., has resigned. He will be succeeded by C. C. Gillett, Pittsburgh, Pa., formerly connected with the Pittsburgh Railways Co.

JOHN C. PEW, president of the Sun Shipbuilding & Drydock Co., Chester, Pa., and vice president of the Sun Oil Corp., Philadelphia, Pa., has been elected vice president of the Columbia Gas & Electric Co., Charleston, W. Va.

EZRA B. WHITMAN, a member of the Maryland State Public Service Commission, has been elected president and a member of the board of directors of the Kentucky Electric Power Co., Nortonville, Ky.

HOMESTEAD VALVE MFG. CO. has appointed the F. A. Herr Co., Buffalo, N. Y., as its representative in the Buffalo and Rochester districts.

HILLS-MCCANNA CO., Chicago, announces the opening of a sales office in charge of Harry Hartling, Room 832, Guardian Life Bldg., Cleveland, Ohio.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., announces that B. M. Horter, formerly of the Philadelphia office, has been appointed manager of the company's Boston office to succeed J. M. Fernald, who has resigned to enter a different business.

THE BURKE ELECTRIC CO., Erie, Pa., announces the appointment of C. A. Cotton, 135 High St., Boston, Mass., as district sales agent for the New England territory.

THE JEFFREY MFG. CO., Columbus, O., announces the election of Robt. W. Gillespie as vice president, assistant general manager and member of the board of directors. Mr. Gillespie has for many years been identified with the Bethlehem Steel Co.

THE SHERMAN CORP., Engineers, Boston, Mass., announces that Raymond Fink, formerly vice president of Pierce, Butler & Pierce, has joined its executive staff.

THE BRIDGEPORT BRASS CO., Bridgeport, Conn., announces the appointment of Wm. J. Butler as salesman of its products in northern New England.

ACCORDING TO recent reports, Detroit is to have a new 45-story office building on the site of the Moffat Building, Fort and Griswold Sts. This will be called the New Penobscot Building and will be erected by the Simon J. Murphy Co. Donaldson & Meier are architects and the engineering and construction work will be supervised by A. L. Struven as owner's representative.

WORK HAS BEEN STARTED on what will be the highest stack in New England at the power station of the paper mills of the S. D. Warren Co., Cumberland Mills, Me. The chimney will rest on a foundation 40 ft. above sea level and will be constructed to a height of 350 ft., a total of 390 ft. above mean low tide. The foundation will be composed of 320 piles, with an average length, or driving depth, of 45 ft. The base will be 34 ft. in width, outside measurements, while the top will have an inside diameter of 18 ft. The only other stacks in New England approximating this height are those at the plants of the Arlington Mills, Lawrence, Mass., textile manufacturers, and the Margrave Electrical Works, Providence, R. I., both of which are 335 ft. high.

UTAH POWER & LIGHT CO. has completed preliminary surveys and estimates for a hydro-electric power development of approximately 1,000,000 hp. on the upper Green River and is about to make application to the Federal Power Commission for license to begin work. It is planned to build a dam 220 ft. high and 800 ft. wide which will control the flow of the river so that a series of smaller dams can be built below it for power production.

WORK HAS ALREADY been started on the $25,000,000 electric power project of the Grand River Hydro-Electric Development Co. at Ketchum, Okla. Four dams are to be built on the bend of the Grand River at Ketchum. It is estimated that about 250,000 hp. can be developed. The company is owned by J. F. Robinson, of Miami, Okla.

THE DUQUESNE LIGHT CO., Pittsburgh, Pa., is planning a new electric generating plant on the Ohio River, near Shippingsport, Pa. The station as planned will contain 9 units and the total development with the transmission system is estimated to cost $30,000,000. Work will be begun early in 1927.

THE EASTERN NEW JERSEY POWER CO., Asbury Park, N. J., has secured permission to consolidate the Brown's Mills Electric Light & Power Co. and the New Egypt Light, Heat, Power & Water Co.

Catalog Notes

FAIRMOUNT pumping station at Cleveland, O., is the subject of a pamphlet just issued by De Laval Steam Turbine Co. of Trenton, N. J. L. A. Quayle, the chief mechanical engineer, describes the type of geared turbine-driven centrifugal pump used, outlines the investigation which resulted in choice of these units and gives the results of tests made. The pumps handle 20 to 75 million gallons a day each at 86 to 400 ft. head and supply bled steam at 3 to 125 lb. for heating business buildings and residences.

THE HAYS CORP., Michigan City, Ind., in a recent catalog, announces its new line of pointer gages for draft pressure and differential measurements. These gages do not employ liquids, floats, gears or magnets. Leveling is unnecessary and gages can be supplied in flat type or edgewise type for any range of pressures.

IN ITS NEW catalog, No. 118, Wheeler Condenser & Engineering Co. of Carteret, N. J., gives an interesting discussion of the factors necessary to consider in intelligent design of condensers such as proper rate of heat transfer, steam penetration among the tubes, velocity of cooling water flow, vacuum to be carried, amount and temperature of cooling water available. The effect of each factor is discussed and the bearing on tube surface, arrangement of tubes, size of tubes, location of condenser, baffling, number of passes, provision for cleaning and auxiliaries for handling air, condensate and cooling water.

One notable feature in the description of details is a new tube layout, designed to utilize the kinetic energy of steam leaving the turbine blades so as to secure steam penetration among the tubes and sweeping out of non-condensible gases. Other features are sections on care and upkeep of condensers, factors controlling corrosion of tubes, use of steam-jet air pumps and characteristics of circulating pumps.

The catalog is an attractive publication of 87 pages and worth careful study.

HERBERT MORRIS, INC., Buffalo, N. Y., in book 104, describes Morris Hand Cranes of various types and sizes, showing details of the crane construction and methods of application, together with tables of dimensions and complete price lists.

H. M. BYLLESBY & Co. has just published a 32-page illustrated book describing the Standard Gas & Electric Co. and its operated and affiliated public utilities. Forty-five photographs of the principal steam and hydro-electric plants, gas plants, substations and the like are reproduced, with a four color map showing the extent of the company's investments.

THE INTERNATIONAL NICKEL Co., New York, in Bulletin 201, discusses properties and applications of nickel and nickel-chromium cast iron, showing photographs of engine and machine parts made of this material. In Bulletin 202 a more detailed and technical discussion is given of the subject of improving gray cast iron with nickel. Here all essential information required by the foundry man metallurgist or engineer is presented with tables, illustrations and commercial applications and instructions for making the nickel or nickel and chromium addition.

NORTON Co., Worcester, Mass., has just published a most attractive and artistic book discussing "Two Norton Achievements and Their Recognition." The first of these was the development, by Aldus C. Higgins, of the electric furnace in which Alundum is made commercially and for which he was awarded the John Scott medal in 1914. The second was the invention of grinding machines by Chas. H. Norton for which he was awarded the same medal in 1925. Photographs of both of these men are reproduced, together with an interesting discussion of their achievements.

"THE LOGIC OF INSULATION," a 16-page illustrated booklet published by Celite Products Co., New York, discusses the difference between refractory and insulating materials, losses due to heat radiation and the application of Sil-O-Cel insulating materials to various types of work. Sil-O-Cel C-3 and Sil-O-Cel C-3 Concrete are described in a four-page leaflet issued by the same company.

THE GALION IRON WORKS & MFG. Co. has just issued a bulletin describing the Galion belt conveyor for loading trucks with coal, gravel, crushed stone, cinders and the like from hopper bottom cars or from a grizzly hopper. It has also issued a bulletin on the Galion 89 E-Z lift grader.

THE MARCH ISSUE of the Cochrane Bulletin, published by Cochrane Corp., Philadelphia, Pa., is a 32-page illustrated treatise on fluid meters, including pipe flow meters for steam, water, air and gases, also V-notch meters, weighing meters and volumetric meters. All of this equipment is described in detail with illustrations and diagrams of operation and much general engineering information on flow of fluids through orifices, pipe nozzles, V-notch meters and the like. The April issue of the bulletin discusses the storage of hot water in connection with exhaust steam heaters. Various arrangements of open feed water heaters with enlarged storage capacity are shown, together with jet heaters, deaerating heaters and connection diagrams for use in paper mills, bleacheries, laundries and the like.

AUTOMATIC PUMPING is the title of a 24-page booklet issued by Barrett, Haentjens & Co., Hazelton, Pa. In contrast to other bulletins of the company, this one treats the subject from a purely technical standpoint, describing several new methods of making centrifugal pumps automatic. Copies may be obtained by asking the company for bulletin 400-A.

PUBLIC SERVICE Co. of Northern Illinois in its 1926 Year Book, just issued, presents interesting data on the development of its properties during the past year, its plans for the future, its work in public relations and personnel development, together with a statement of income and expenses and a map of the district served by its transmission lines.

COCHRANE DEAERATING HEATERS for stopping corrosion in piping, boilers and economizers by removing dissolved air from the water are described in a leaflet issued by the Cochrane Corp., Philadelphia, Pa.

GRAPHICALLY DEPICTING by word and photograph how chain driven machine tools increase output, produce better quality, consume less power and decrease tool maintenance, a new 36-page book entitled "Machine Tool Drives" has recently been issued by Link-Belt Co., Chicago, Ill.

PHOENIX AUTOMATIC SELF-CLEANING Constant-Effect Air Filter, which consists of a motor-driven traveling screen, the lower drum traveling in a bath of Coatol, is described and illustrated in a bulletin received from Drying Systems, Inc., Chicago, Ill.

THE BORDEN Co., Warren, O., in a recent bulletin, describes the Beaver Square End Pipe Cutter designed to cut pipe without leaving burrs and thus eliminating the necessity of reaming.

THE WORTHINGTON LOCOMOTIVE Feed Water Heater and Boiler Feed Pump is described in a well illustrated bulletin issued by Worthington Pump and Machinery Corp., New York, N. Y.

BYLLESBY ENGINEERING & MANAGEMENT CORP. has just published an attractive 16-page booklet for the Louisville Gas & Elec. Co., describing the 135,000-hp. hydro-electric development at the falls of the Ohio River.

"WORKMANSHIP APPLIED TO WALWORTH SIGMA STEEL PRODUCTS" is the title of Bulletin No. 8 just received from Walworth Co., Boston, Mass.

AMERICAN BLOWER Co., Detroit, Mich., has just issued a well illustrated 32-page bulletin describing the applications of American Blower fans in stores, factories, offices, theatres and homes. The American Blower Man-Cooling fan, designed particularly for industrial plants where workmen are often exposed to great heat, is described in a separate illustrated folder.

KIRK & BLUM BLOWER SYSTEMS for collecting, ventilating and conveying various materials are described and illustrated in an attractively printed 50-page bulle-

tin issued by the Kirk & Blum Mfg. Co., Cincinnati, O. The bulletin contains a thorough discussion of the fundamental principles of blower engineering and some interesting photographs of blower equipment as installed in all types of plants. In many cases, these systems are used for handling sawdust and wood waste, although they can be used for handling dust and many other types of light materials and for removing fumes and gases from industrial plants.

FUNDAMENTAL PROBLEMS of Heat Conservation in Oil Refineries is the title of the first of a series of six bulletins to be issued by the Ross Heater and Mfg. Co. of Buffalo, N. Y. These will deal with the application of heat exchange apparatus to the petroleum industry and incidentally will discuss many features which are applicable to heat exchange in steam and refrigerating plants, showing the advantages of the shell and tube type. The series of bulletins will be sent to anyone interested on request.

ANDREWS-BRADSHAW Co., Pittsburgh, Penna., has just prepared a 48-page, fully-illustrated catalog on the Tracyfier. It covers the necessity for cleaning steam and the benefits to be derived from the use of steam that is entirely free from boiler water or dust. The construction of the Tracyfier is clearly shown and its principles of operation are carefully outlined. The catalog includes a discussion of the effect of boiler water treatment and blow-down on steam quality. A section describes the application of the Tracyfier Gas and Vapor Scrubber.

"INDUSTRY'S ELECTRICAL PROGRESS" is the title of the 36-page booklet recently issued by the Cutler-Hammer Mfg. Co., of Milwaukee, Wis.

This tells the story of progress made in the development of motor control apparatus and points out that the comparative advantages which electric power brings to industry lie in the effectiveness with which electricity is utilized. It gives numerous examples of accomplishments of correct motor control equipment and many photographs of actual installations are shown.

COFFIN STANDARD SLUICE GATES are described and attractively illustrated in an 84-page booklet sent by Coffin Valve Co., Neponset, Mass. This booklet discusses standard sizes, determination of size of gate, design and type of sluice gates and frames, details of construction of various types showing photographs and drawings of applications of these gates, methods of operating them and specifying them and comments on erection in the field.

THE ECLIPSE SMOKE AND COMBUSTION INDICATOR, a device to enable the boiler room operator to see whether or not his stack is smoking and the McNeill Liquid Level Gage, employing the Mercury U-tube principle in a gage that can be located at any point remote from the level of liquid to be measured—in steam boilers or other vessels —are described in leaflets issued by Boiler Room Improvement Co., Chicago, Ill.

LOW LEVEL EDUCTOR CONDENSERS, designed to handle steam and vapor under high vacuum, are described in Bulletin 5-B, just issued by Schutte & Koerting Co., Philadelphia, Pa.

THE AMERICAN BLOWER CO. has just issued bulletin No. 7003, superseding No. 1103, describing American H. S. fans. These are designed for high speeds for forced draft work and the illustrations and text explain the streamline design, the design of impellers and the construction of the scroll or casing, giving curves of characteristics and dimension sheets of all the standard arrangements. These fans are suitable for direct drive by motor or steam turbine.

PROTECTION FOR TRANSFORMERS, oil circuit breakers, electrolytic arresters and feeder regulators by drying and cleaning the insulating oil, using the Hydroil centrifugal purifiers and dehydrators is discussed in a bulletin of the Hydroil Sales Corp., Gashen, Ind.

ORTON CRANE & SHOVEL CO., Chicago, Ill., in a recent bulletin, describes models "T" and "E" convertible cranes. These are locomotive cranes equipped with the spring backed crawling tread and the bulletin describes and illustrates all possible applications of this equipment.

NEEMES STOKER for manual operation is described in Bulletin 104 issued by Neemes Foundry, Inc., Troy, N. Y.

COMPREHENSIVE MAPS of the public utility systems of the Standard Gas & Elec. Co. and Northern States Power Co. have just been issued, printed in four colors and showing the communities served, location of power plants and transmission systems and kinds of service.

KIELEY & MUELLER, INC., New York City, as a supplement to its general catalog, has issued an 18-page booklet containing data on its most widely known products, such as regulating valves, float valves, traps and pump governors.

THE D. CONNELLY BOILER CO., in the 1926 issue of its catalog, which has just been issued, describes the design and construction of the Connelly water tube boiler. The bulletin is illustrated with attractive photographs and contains data from boiler tests and diagrams of settings.

WHITING CORP., Harvey, Ill., has just issued bulletin No. 175, a condensed catalog of equipment manufactured by Whiting Corp. and subsidiaries. Photographs, diagrams and text describe Whiting cranes, cupola furnaces and accessories, tumbling mills, core oven equipment, convertors, foundry equipment, hydraulic gates and hoists, Grindle pulverized coal systems and equipment for chemical plants.

"DIESEL ENGINES FOR CENTRAL STATIONS" is the title of an attractive bulletin issued by McIntosh & Seymour Corp., Auburn, N. Y. This discusses the advantages of such applications, illustrated by photographs of central stations using this equipment, and giving comparisons of Diesel and steam engine data.

TO THOSE INTERESTED in steel and iron products, The Little Red Ball, a story of wrought iron, issued by the A. M. Byers Co., Pittsburgh, Pa., will be found attractive reading as well as instructive as to the characteristics of wrought iron and its advantages. A copy can be had by writing to the A. M. Byers Co.

ARMSTRONG MACHINE WORKS, Three Rivers, Mich., has just issued catalog E covering Armstrong traps. Construction of the traps to prevent air binding, valve scoring and clogging is discussed in detail and full information about the various sizes and styles of traps is given with data on intallation, connection and a repair parts list.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Today's Cause and Tomorrow's Effects

Since the beginning of mankind's ascendancy, we have been prone to dodge the laws of cause and effect.

Indeed, it may be said that the power to distinguish the logical cause of a given effect may be taken as a standard by which to measure the advance which individuals and civilization have made.

Men, when they were but little higher than the beasts, were governed by instinctive connections between cause and effect.

Today the struggle goes on between instinctive control of actions and their logical control.

Each of us may find that we are inclined to attribute results to events or causative forces that are most flattering to our vanity, or even to put the whole burden of untoward effects upon an act of Providence, rather than to search out the real cause or recognize the logical results of our own acts.

Modern science harbors nowhere in its scheme of things the possibility that there can be an effect without a cause. And regardless of the apparent lack of connection with any known or conceivable cause, the scientific mind immediately reacts from any effect to search out and prove the cause from which it comes.

Science has been brought into the great industries of this country to an extent never before equalled and in no industry has this movement gone farther than in the generation, distribution and utilization of light, heat and power.

Through such scientific connection between cause and effect as prevails in the realm of power, the people as a whole are having made visible to them the logical connection between cause and effect.

Mass thought or mass consciousness only too often lags far behind individual thinking. In a group acting individually there may be a large majority who assent to a given proposition and yet that group as a whole may act contrary to the majority thought of the individuals of that group.

In public affairs, most directly under the control of all the people, we find men, machines, buildings, schools, laws and their enforcement that would not be tolerated by our people in their private or in their corporate affairs.

Paradoxial as it may seem, one of the greatest problems of modern life is to bring group thought up to the level of the majority of the individual thought represented by that group.

Think for a moment what a fine world this would be if the actual practice of government activities, corporate affairs, social relations and judicial administration were up to the standards that the majority of all the people really would like to have them.

For the people, the common people, the mass of us all, have innate common sense and practicable ideals that are far higher than most leaders recognize or are indicated by our mass actions.

Problems that turn the hair of statesmen gray, that make executives of businesses age before their time, that cause us all much irritation, would all dissolve as though by magic if the majority thought of the mass of us could solidify into mass consciousness and then into mass action.

There is a wide gap between logical thought and instinctive thought, and because modern life requires so many decisions of us all every day, it follows that in large part our actions must be instinctive or there would be no action at all.

Mechanical power has been forcing logical thought to the foreground. Men who have seen new power plants cut the cost of power in their own factories; or have learned to press a button for light and heat; or have been swiftly transported by dependable train service; or have invested in the securities of power and received dividends from them, and who have enjoyed new luxuries and new freedom by the help of power also have come into a new spirit of mental and physical solidarity.

In the last decade alone power has made such great advances in its service to humanity that it is welding men into a unity of thought, creating a mass consciousness that may well be expected to influence the destinies of the race more powerfully than all the wealth, comfort and conveniences it has created.

Already men with the scientific, the engineering viewpoint, men who find the cause of effects and face the facts as they find them, and from these facts are able to build new and better organizations, plants and companies, are being put in the seats of the mighty in both public and private affairs.

Already the power of leadership of the men of mechanical power is being recognized in citizenship, in finance and in social problems.

With this go added responsibilities to power plant men. For you and your plants are becoming not only a great industrial influence but a community and national influence.

In this season of vacation are you looking forward to making the most of your opportunity?

Greater knowledge as an engineer plus the ability to translate what modern power plants can do for manufacturers, cities, the nation and the people concerned in these units, open the way to a greater advancement and influence. And future developments are bound to offer even greater opportunities to men who have the knowledge and initiative to grasp them.

What will your power plant be this winter? next year? a decade from now? By it you shall advance or be swept aside by the advance of others.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Nordberg Mfg. Co., Milwaukee.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR FILTERS.
Cooling Tower Co., Inc., New York.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Forge Co., Buffalo.
Cooling Tower Co., Inc., The, New York.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Williams Gauge Co., The, Pittsburgh.
Wright-Austin Co., Detroit.

ARCHES, BOILER COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Detrick Co., M. H., Chicago.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Alvey-Ferguson Co., Inc., The, Cincinnati, O.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.

BEARING METAL.
Strong, Carlisle & Hammond Co., The, Cleveland, Ohio.

BEARINGS, ROLLER.
Timken Roller Bearing Co., The, Canton, Ohio.

BELT CONVEYORS.
Jeffrey Mfg. Co., The, Columbus, O.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING.
Goodyear Tire & Rubber Co., Inc., The, Akron, Ohio.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN AND FURNACE.
Air Preheater Corp., The, New York.
Buffalo Forge Co., Buffalo.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Boston.

BLOWERS, PORTABLE.
Buffalo Forge Co., Buffalo.
Clements Mfg. Co., Chicago, Ill.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 162

Sturtevant Co., B. F., Boston.

BLOWERS, TUBE.
Diamond Power Specialty Corp., Detroit.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Sherwood Mfg. Co., Buffalo.

BLOWERS, TURBINE.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASINGS.
Walsh & Weidner Boiler Co., The, Chattanooga.

BOILER COMPOUNDS.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chem. Co., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEEDWATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., New York.
Permutit Co., The, New York.
Scaife & Sons Co., Wm. B., Pittsburgh.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Walsh & Weidner Boiler Co., The, Chattanooga.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.

BOILERS.
Babcock & Wilcox Co., New York.
Badenhausen Corp., Cornwells Heights, Pa.
Bigelow Co., The, New Haven.
Brownell Co., The, Dayton, Ohio.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Freeman Mfg. Co., Racine, Wis.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Nuway Boiler & Engineering Co., Chicago.
Springfield Boiler Co., Springfield, Ill.
Union Iron Works, Erie, Pa.
Walsh & Weidner Boiler Co., The, Chattanooga.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., The, Saginaw, Mich.

BOLTS AND NUTS.
International Nickel Co., New York, N. Y.

BREECHINGS.
Connery & Co., Inc., Philadelphia.
Littleford Bros., Cincinnati.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., The, Columbus, O.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAM SHELL.
Orton Crane & Shovel Co., Chicago.

BUCKETS, COAL HANDLING.
Jeffrey Mfg. Co., The, Columbus, O.
Orton Crane & Shovel Co., Chicago.

CARRIERS, PIVOTED BUCKET.
Jeffrey Mfg. Co., The, Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Erie City Iron Works, Erie, Pa.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
International Nickel Co., New York.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

CEMENT GUNS.
Cement-Gun Co., Inc., The, Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York, N. Y.
Bigelow Co., The, New Haven.
Springfield Boiler Co., Springfield, Ill.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The, Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUNDS.
Dearborn Chemical Co., Chicago.

COAL AND ASH HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Alvey-Ferguson Co., Inc., The, Cincinnati, O.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.